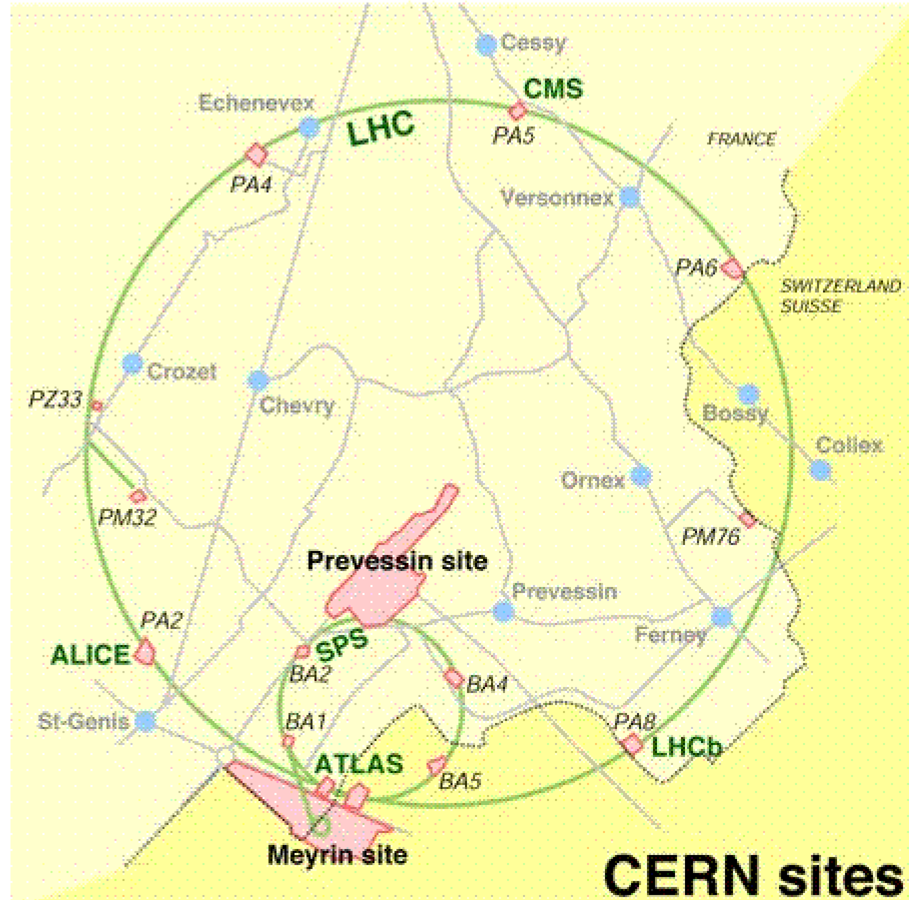
High Energy Dilepton Experiments

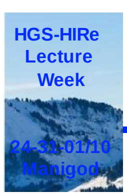
Alberica Toia

Physics Department
CERN

SPS @ CERN

- SuperProtonSynchrotron (since 1976)
  - parameters
    - circumference: 6.9 km
    - beams for fixed target experiments
      - protons up to 450 GeV/c
      - lead up to 158 GeV/c
  - past
    - SppS proton-antiproton collider → discovery of vector bosons $W^{\pm}$, Z
  - now
    - injector for LHC
  - experiments
    - Switzerland: west area (WA)
    - France: north area (NA) → dileptons speak french!





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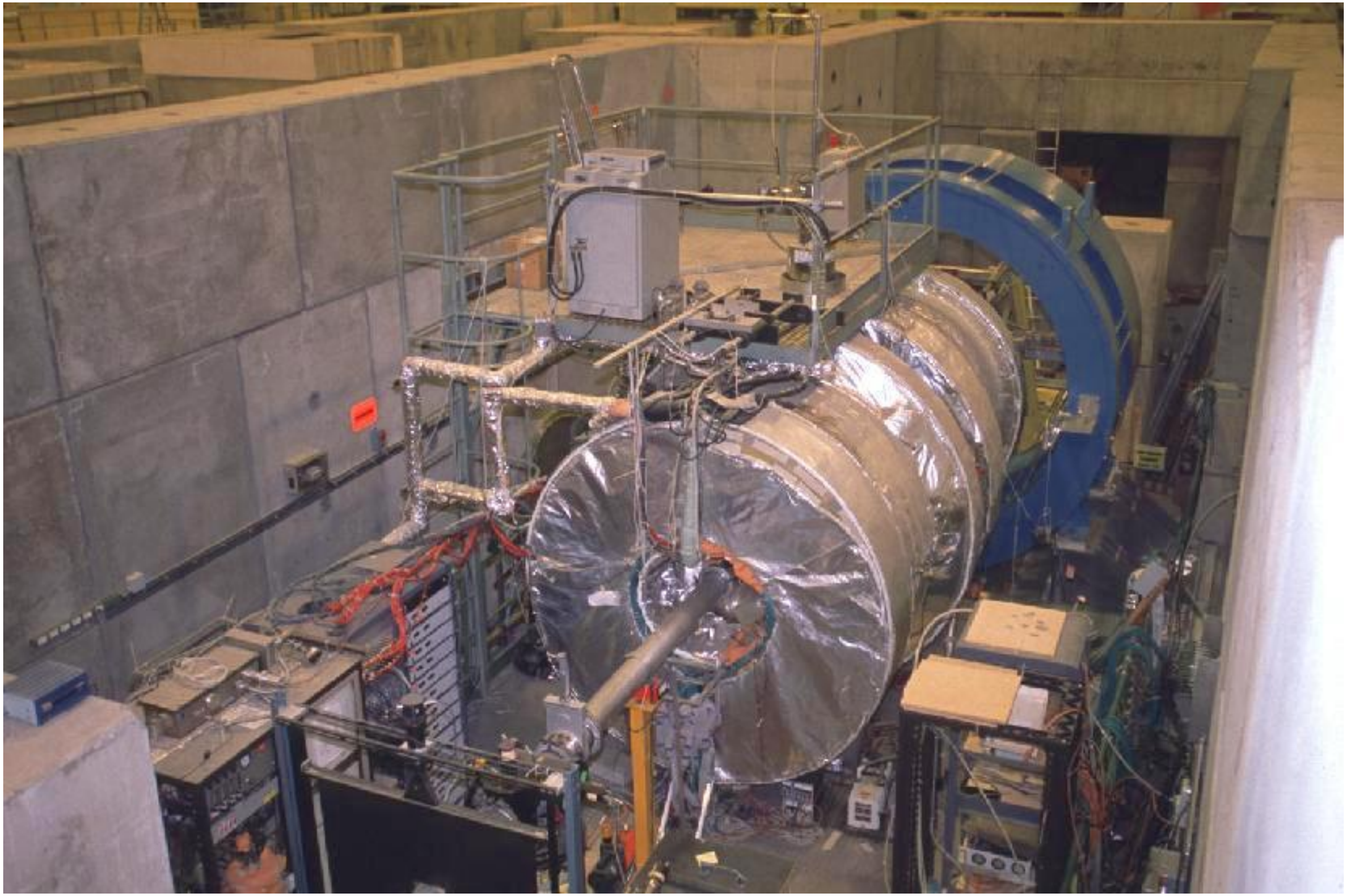
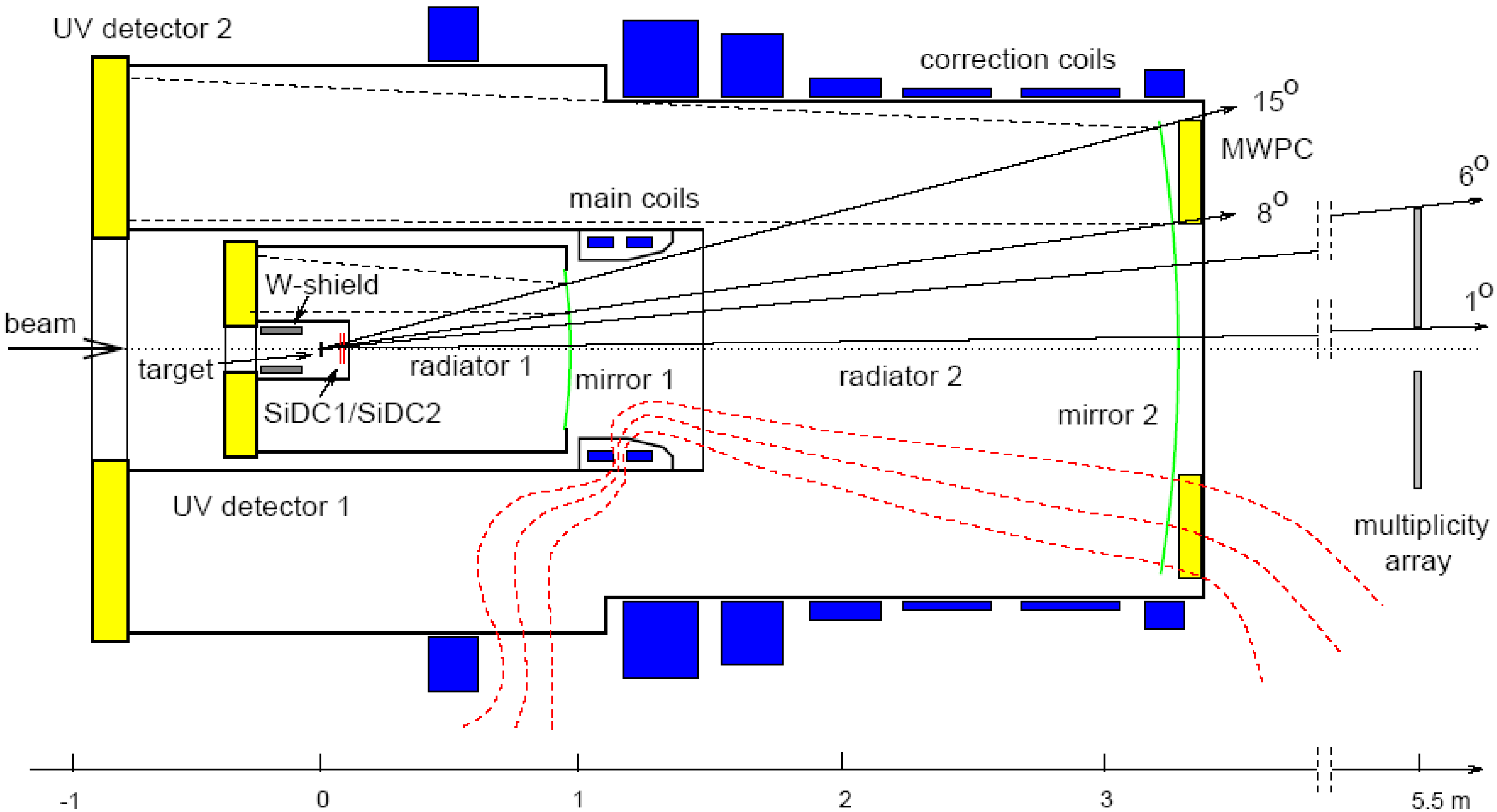
Dilepton experiments @ SPS

Experiment		System	Mass range	Publications
HELIOS-1	μμ ee	p-Be (86)	low mass	Z.Phys. C68 (1995) 64
HELIOS-3	μμ	p-W,S-W (92)	low & Intermediate	E.Phys.J. C13(2000)433
CERES	ee	pBe, pAu, SAu (92/93) Pb-Au (95) Pb-Au (96)	low mass	PRL (1995) 1272 Phys.Lett. B (1998) 405 Nucl.Phys. A661 (1999) 23
CERES-2	ee	Pb-Au 40 GeV (99) Pb-Au 158 GeV (2000)	low mass	PRL 91 (2002) 42301 preliminary data 2004
NA38/ NA50	μμ	p-A, S-Cu, S-U, Pb-Pb	low (high m_T) intermediate	E.Phys.J. C13 (2000) 69 E.Phys.J. C14 (2000) 443
NA60	μμ	p-A, In-In (2002,2003) p-A (2004)	$>2m_\mu$	PRL 96 (2006) 162302

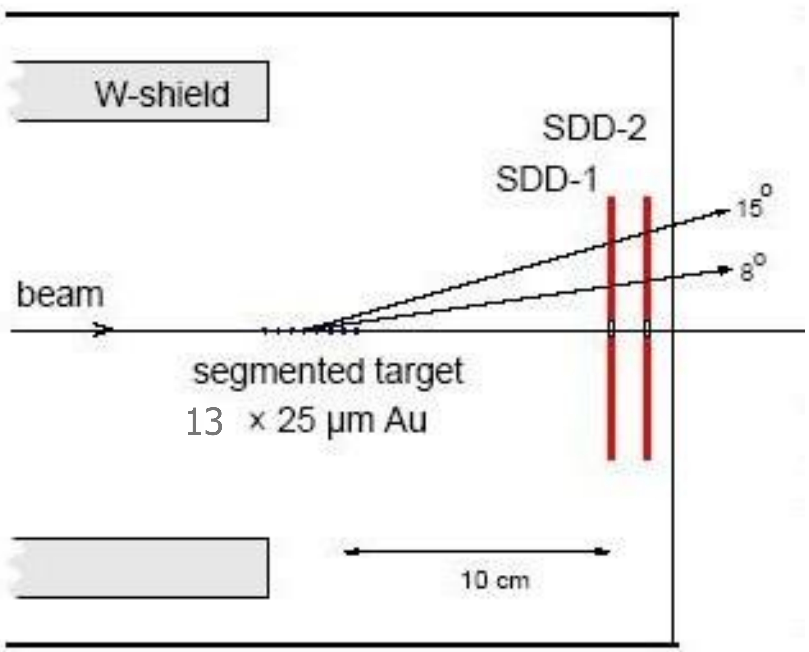
The CERES/NA45 experiment

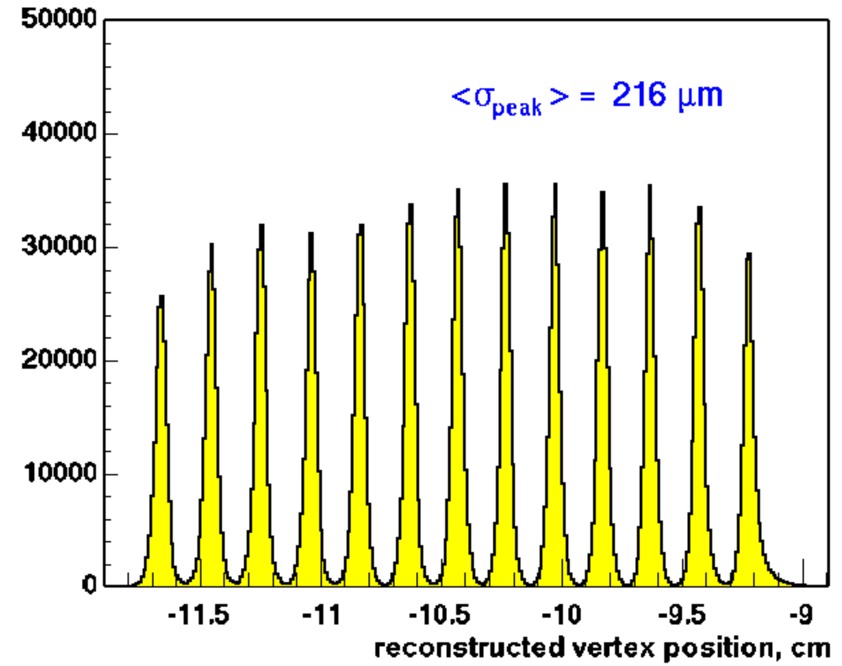


Experimental setup: CERES-1



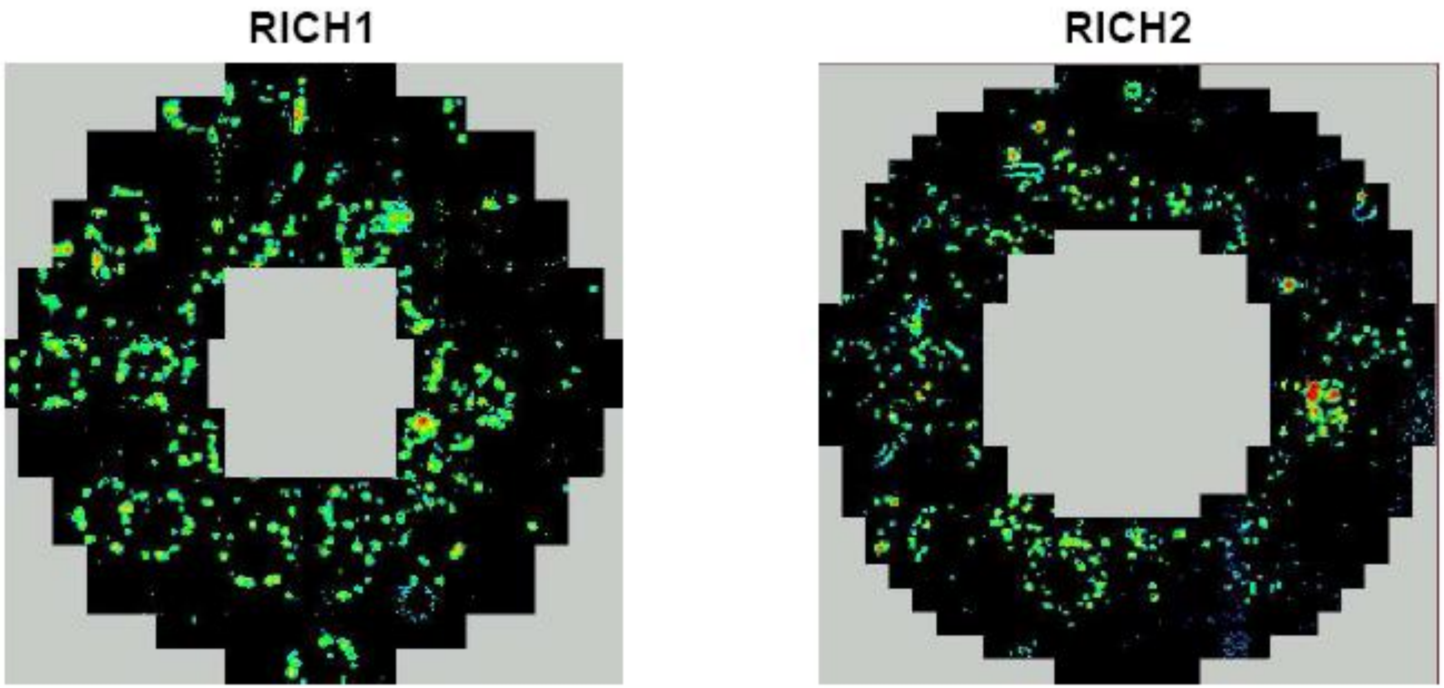
Target region





- **segmented target**
  - **13 Au disks (thickness: 25 μm; diameter: 600 μm)**
- **Silicon drift chambers:**
  - **provide vertex: $\sigma_z = 216\ \mu m$**
  - **provide event multiplicity ($\eta = 1.0 - 3.9$)**
  - **powerful tool to recognize conversions at the target**

Electron identification: RICH



- main tool for electron ID
- use the number of hits per ring (and their analog sum) to recognize single and double rings

Dielectron analysis strategy

tracking

↓

electron identification

↓

π^0-Dalitz and γ-conversion rejection

↓

pairing

↓

subtraction of background
(like-sign or mixed events)

↓

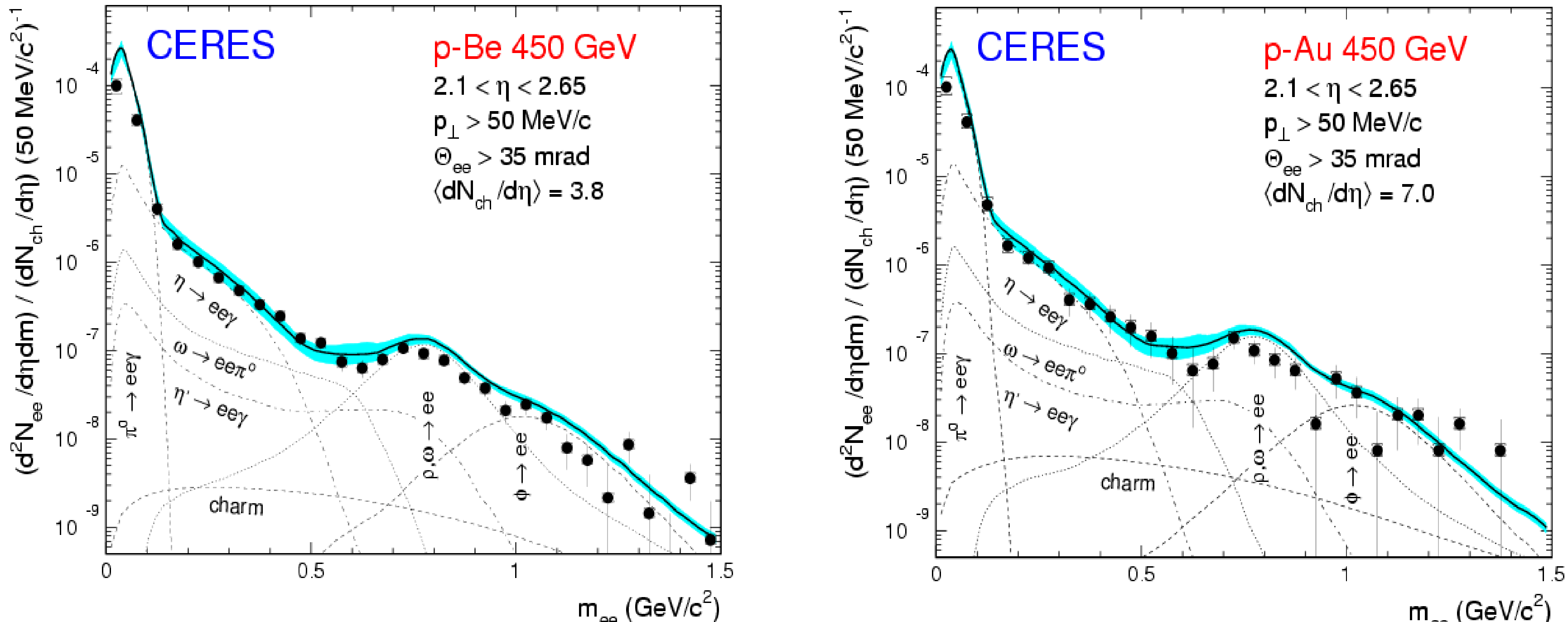
efficiency correction

↓

mass spectrum

e^+e^- in p+Be & p+Au collisions

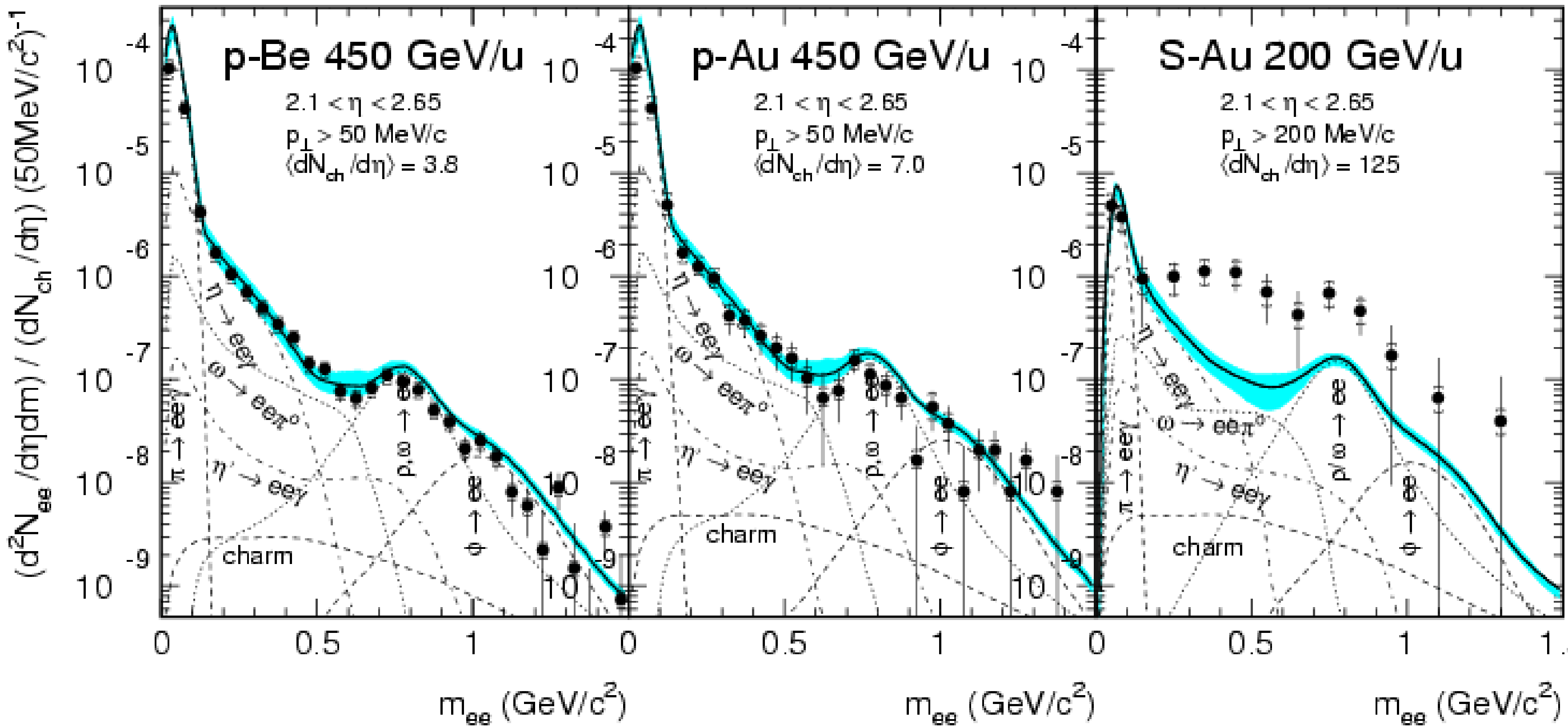
- dielectron mass spectra and expectation from a 'cocktail' of known sources
  - Dalitz decays of neutral mesons ($\pi^0 \rightarrow \gamma e^+e^-$ and $\eta, \omega, \eta', \phi$)
  - dielectron decays of vector mesons ($\rho, \omega, \phi \rightarrow e^+e^-$)
  - semileptonic decays of particles carrying charm quarks



→ dielectron production in p+p and p+A collisions at SPS well understood in terms of known hadronic sources

What about heavy-ion collisions?

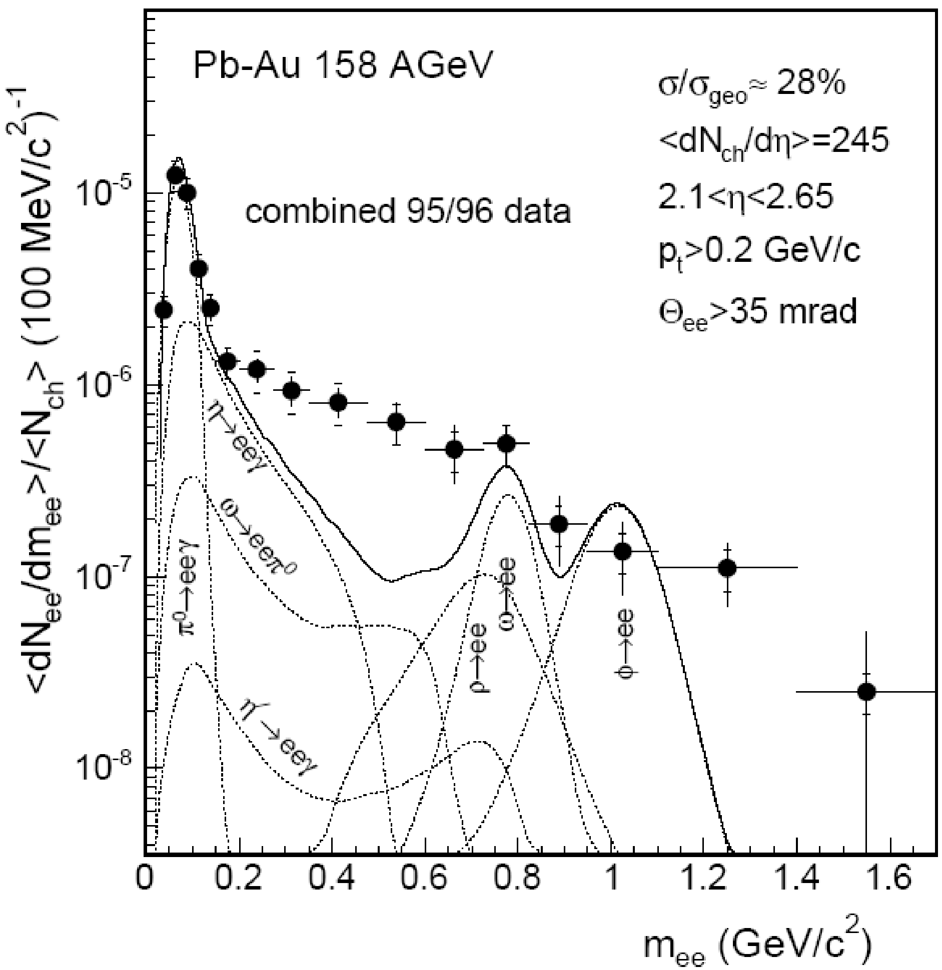
CERES PRL 92 (95) 1272



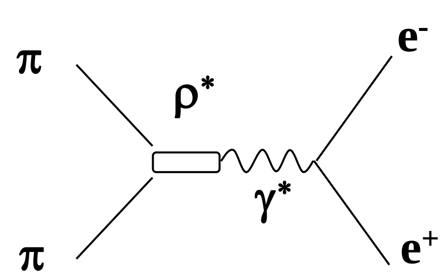
- discovery of low mass e^+e^- enhancement in 1995
  - significant excess in S-Au (factor ~5 for m>200 MeV)

As heavy as it gets: Pb+Au

CERES Eur.Phys.Jour. C41(2005)475

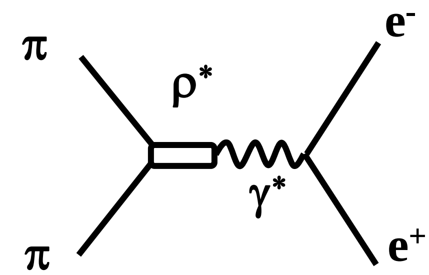


- dielectron excess at low and intermediate masses in HI collisions is well established
  - onset at ~2 m_π → π-π annihilation?
  - maximum below ρ meson near 400 MeV
  - → hint for modified ρ meson in dense matter



π-π annihilation: theoretical approaches

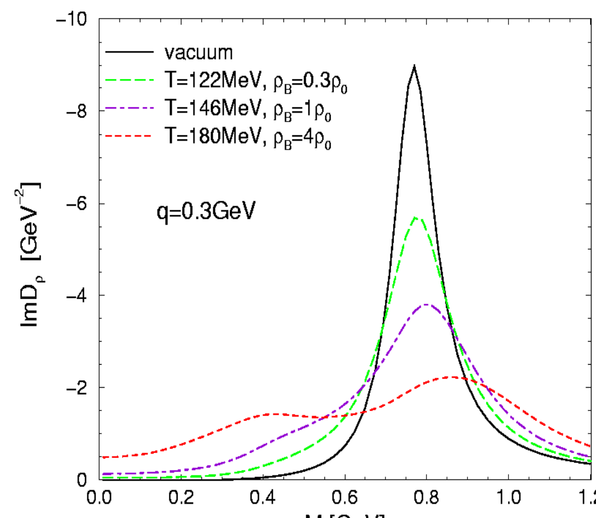
- low mass enhancement due to $\pi\pi$ annihilation?
  - spectral shape dominated ρ meson



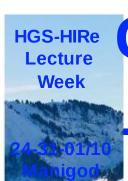
- vacuum ρ
  - vacuum values of width and mass
- in-medium ρ
  - Brown-Rho scaling

$$\frac{m_\rho^*}{m_\rho} \approx \left(\frac{<\bar{q}q>_{\rho^*}}{<\bar{q}q>_0}\right)^{1/3} = 1 - 0.16\frac{\rho^*}{\rho_0}$$

    - dropping masses as chiral symmetry is restored
  - Rapp-Wambach melting resonances
    - collision broadening of spectral function
    - only indirectly related to CSR
  - medium modifications driven by baryon density

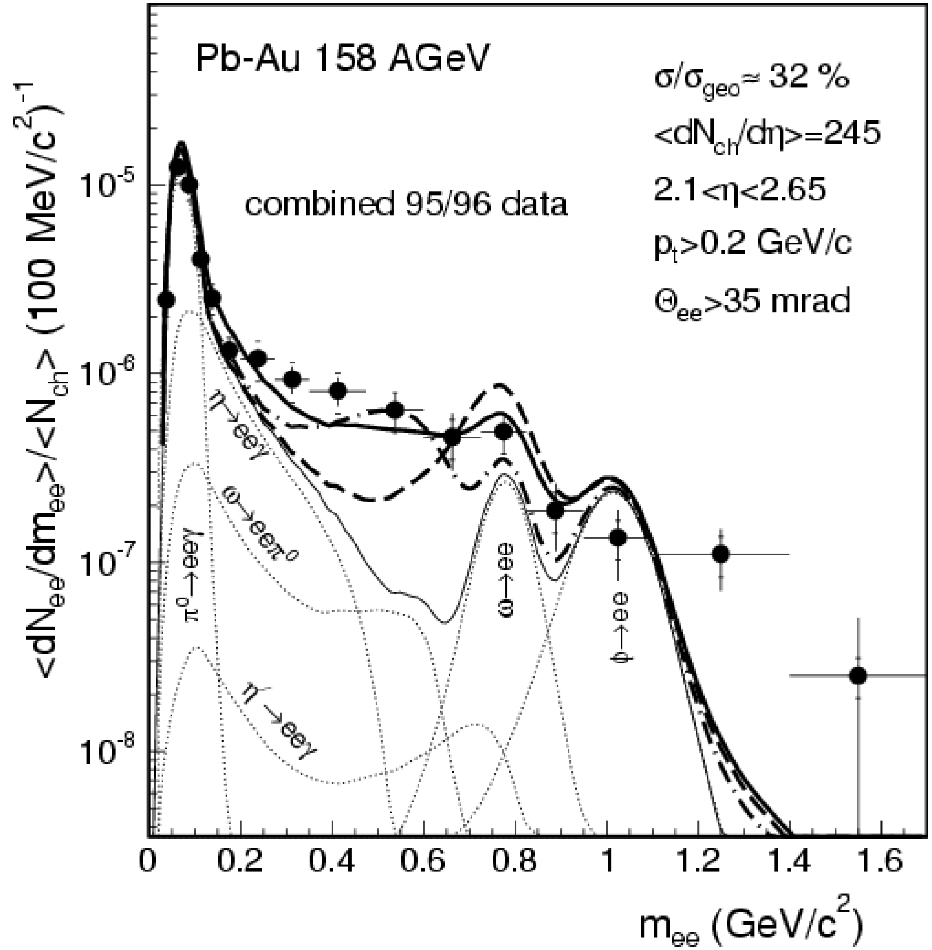


- model space-time evolution of collision



Theory versus CERES-1 data

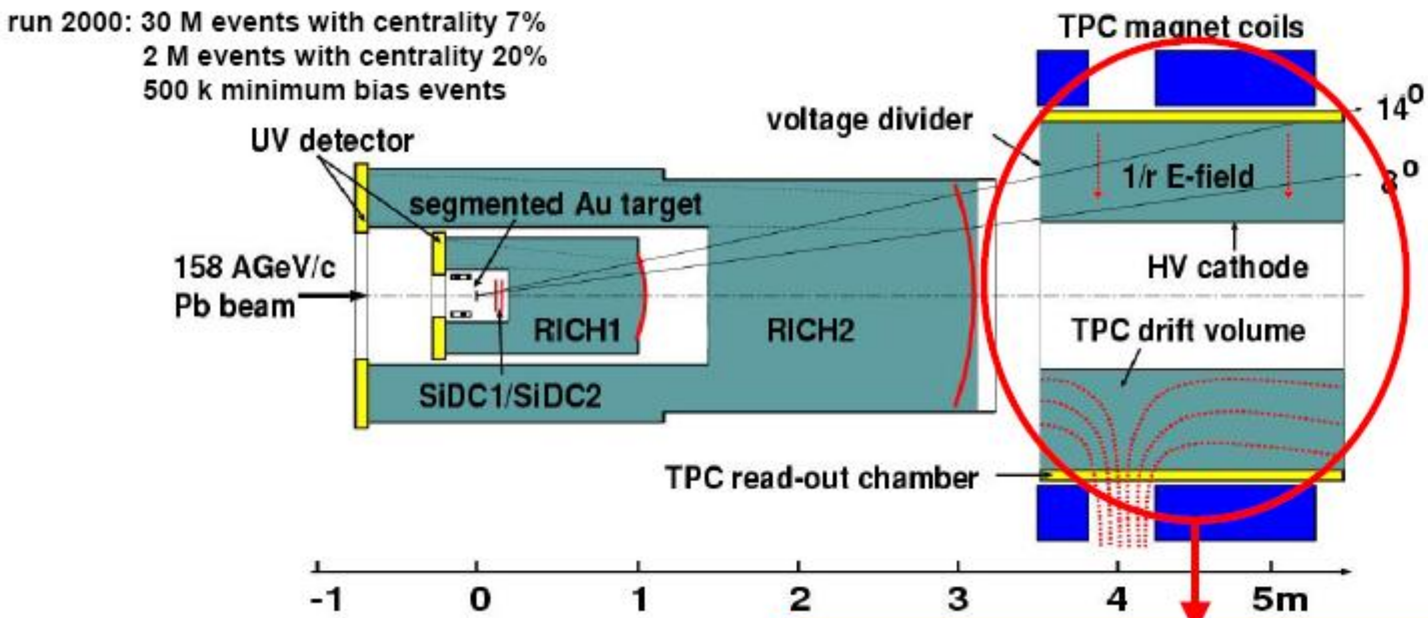
- attempt to attribute the observed excess to
  - vacuum ρ meson (- - - -)
    - inconsistent with data
    - overshoot in ρ region
    - undershoots @ low mass
  - modification ρ meson
    - needed to describe data
    - data do not distinguish between
    - broadening or melting of ρ-meson (Rapp-Wambach)
    - dropping masses (Brown-Rho)



- indication for medium modifications, but data are not accurate enough to distinguish models

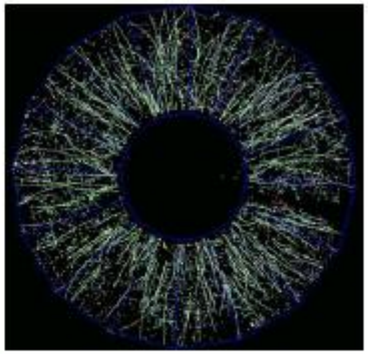
- largest discrimination between ρ/ω and φ
  → need mass resolution!

CERES-1 → CERES-2



- addition of a TPC to CERES
  - improved momentum resolution
  - improved mass resolution
  - dE/dx → hadron identification and improved electron ID
  - inhomogeneous magnetic field → a nightmare to calibrate

radial drift TPC: momentum and energy loss

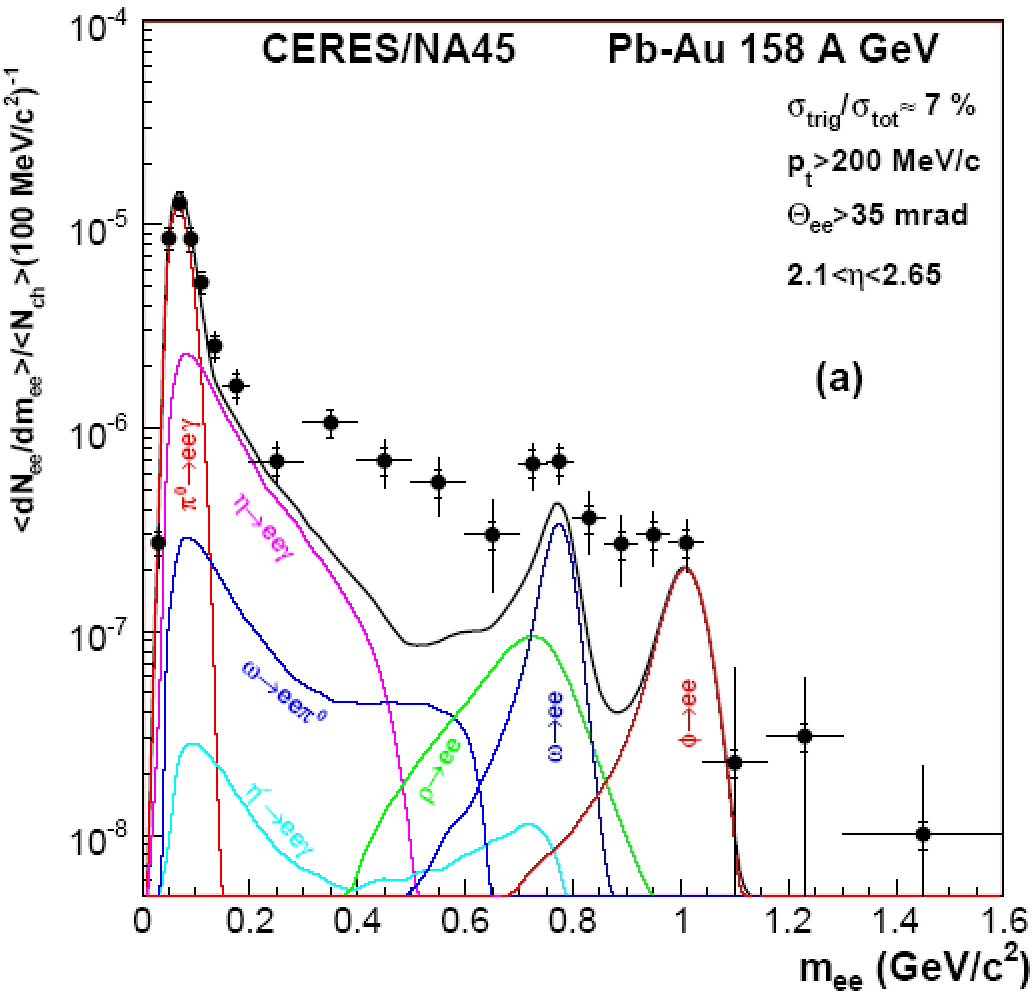


$\Delta p/p = 2\% \oplus 1\% * p/\text{GeV}$

$\Delta m/m$ = 3.8 % for ϕ

$\Delta(dE/dx)/(dE/dx)$ = 10%

CERES-2 result



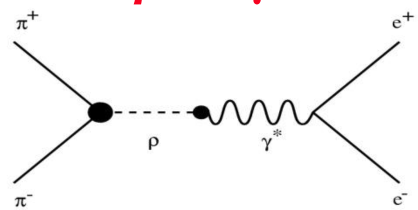
- the CERES-1 results persists
  - strong enhancement in the low-mass region
  - enhancement factor

    (0.2 < m < 1.1 GeV/c^2)

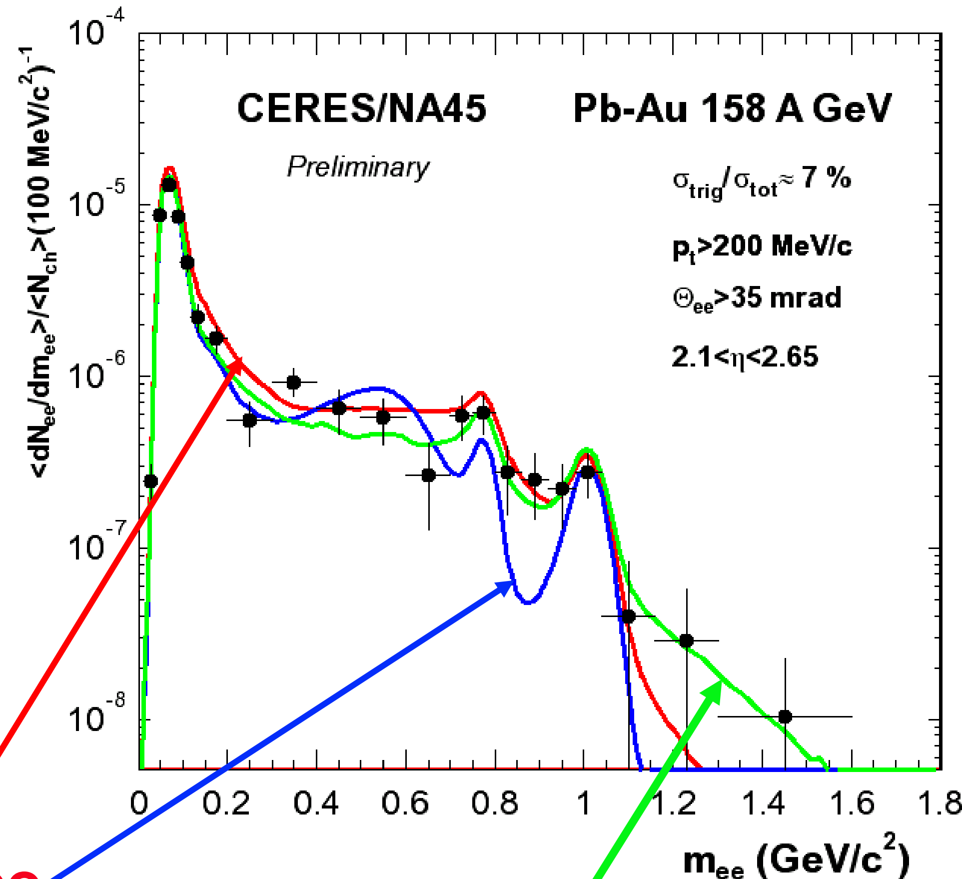
    → 3.1 ± 0.3 (stat.)
- but the improvement in mass resolution isn't outrageous

Dropping mass, broadening, or thermal radiation

- interpretations invoke
  - $\pi^+\pi^- \rightarrow \rho \rightarrow \gamma^* \rightarrow e^+e^-$



- thermal radiation from hadron gas
- vacuum ρ not enough to reproduce the data



* in-medium modifications of ρ:

- ❖ broadening ρ spectral shape
  (Rapp and Wambach)
- ❖ dropping ρ meson mass
  (Brown et al)

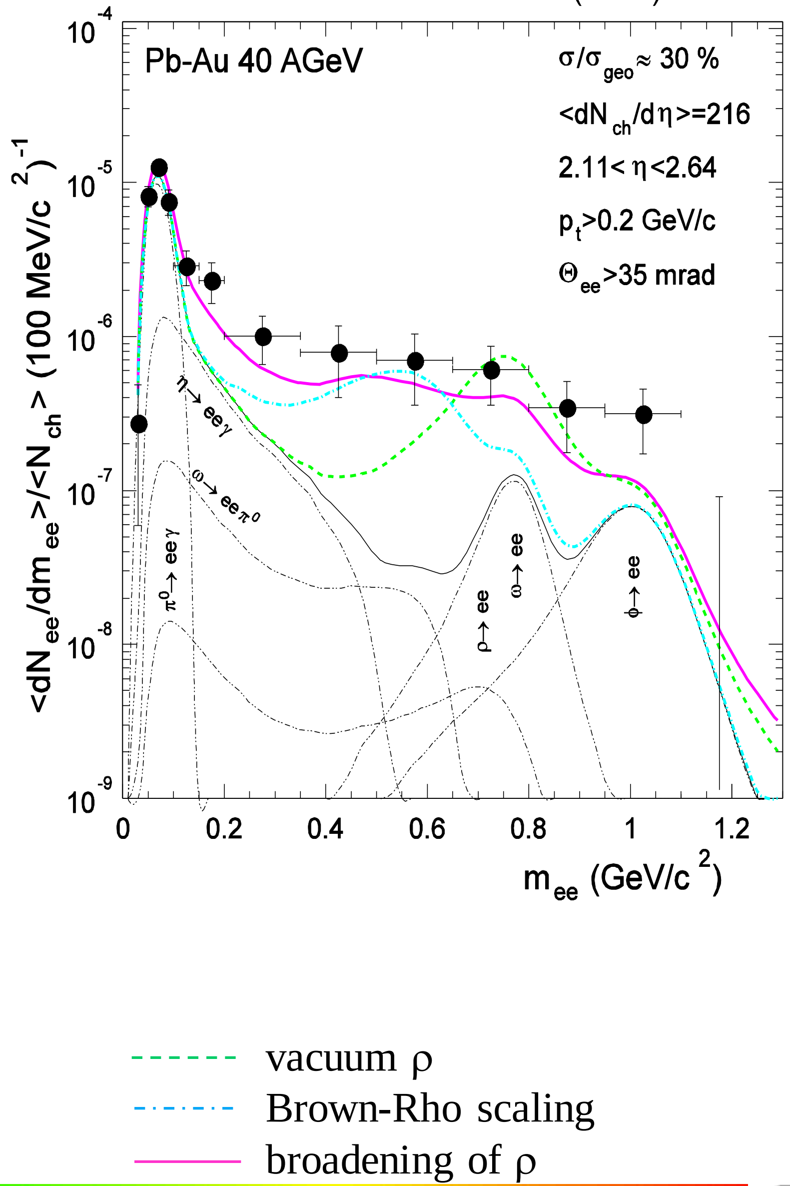
❖ thermal radiation

e^+e^- yield calculated from qq annihilation in pQCD
(B.Kämpfer et al)

CERES @ low energy (40 GeV/c)

- data taking in 1999 and 2000
  - improved mass resolution
  - improved background rejection
  - results remain statistics limited
- Pb-Au at 40 AGeV
  - enhancement for m_{ee}> 0.2 GeV/c^2
    - 5.9±1.5(*stat*)±1.2(*sys*)±1.8(*decay*)

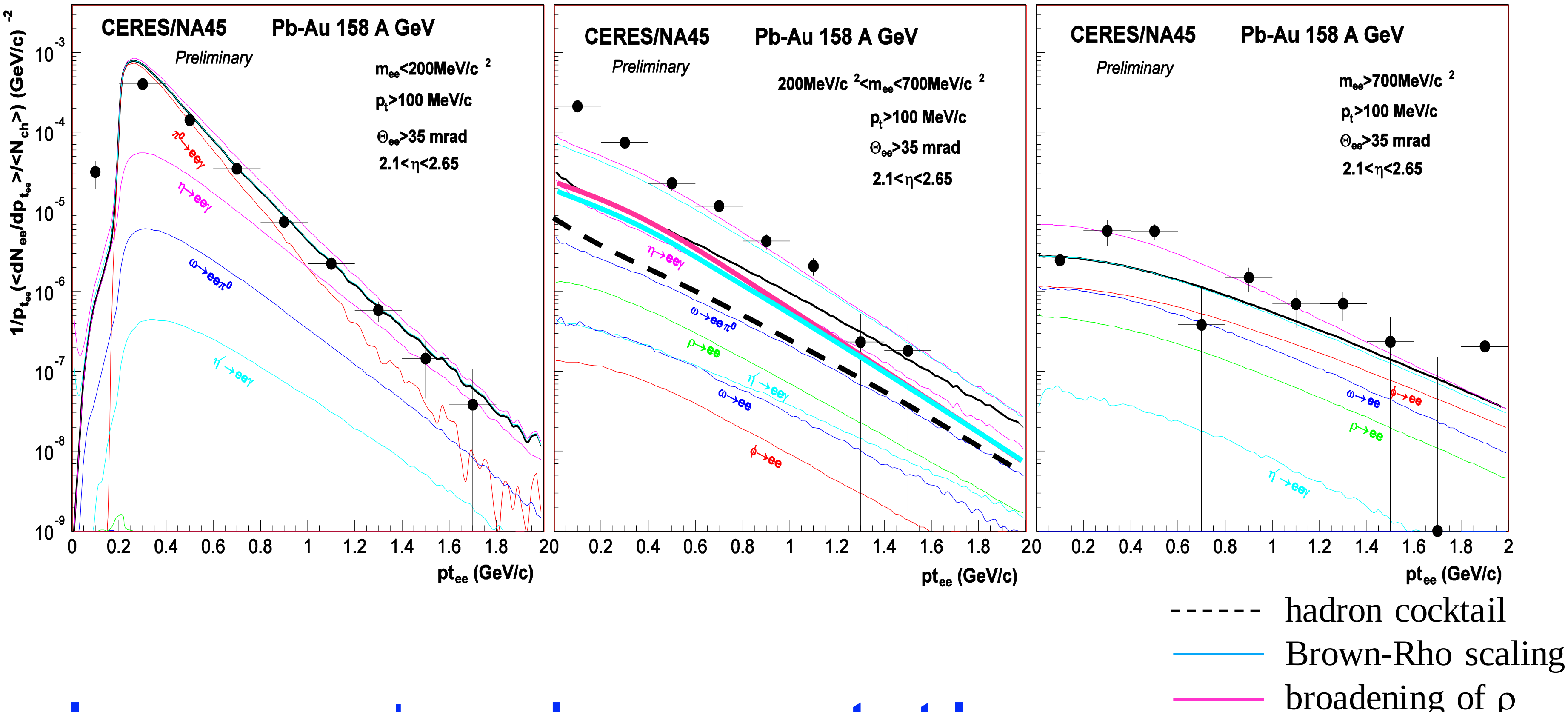
PRL 91 (2003) 042301



strong enhancement at lower √s or larger baryon density

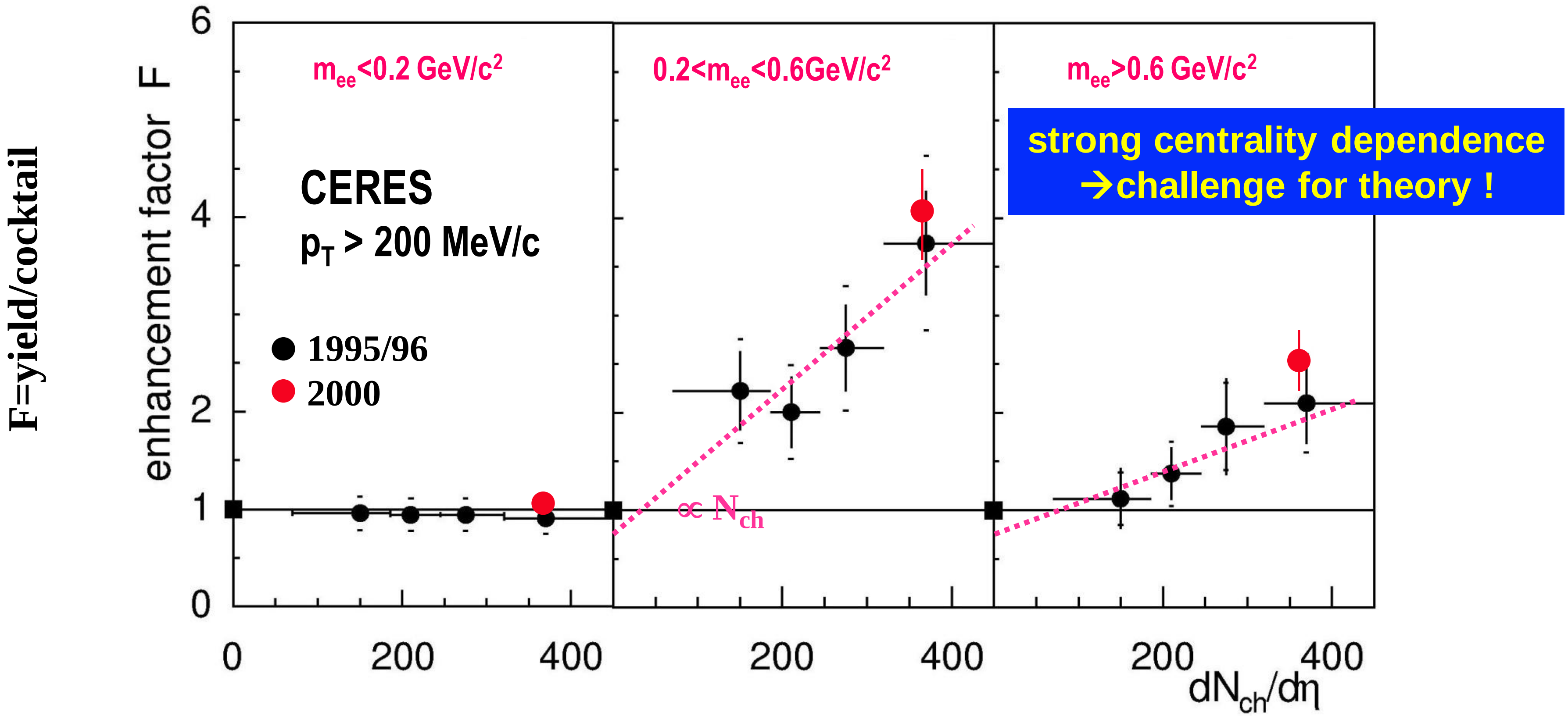
And what about p_T dependence?

m_{ee}<0.2 GeV/c^2 | 0.2<m_{ee}<0.7 GeV/c^2 | m_{ee}>0.7 GeV/c^2



- low mass e^+e^- enhancement at low p_T
  - qualitatively in a agreement with ππ annihilation
  - p_T distribution has little discriminative power

Centrality dependence of excess



- naïve expectation: quadratic multiplicity dependence
  - medium radiation ∝ particle density squared
- more realistic: smaller than quadratic increase
  - density profile in transverse plane
  - life time of reaction volume

What did we get from CERES?

- first systematic study of e^+e^- production in elementary and HI collisions at SPS energies
  - pp and pA collisions are consistent with the expectation from known hadronic sources
  - a strong low-mass low-p_T enhancement is observed in HI collisions

→ consistent with in-medium modification of the ρ meson

→ data can't distinguish between two scenarios
  - → dropping ρ mass as direct consequence of CSR
  - → collisional broadening of ρ in dense medium

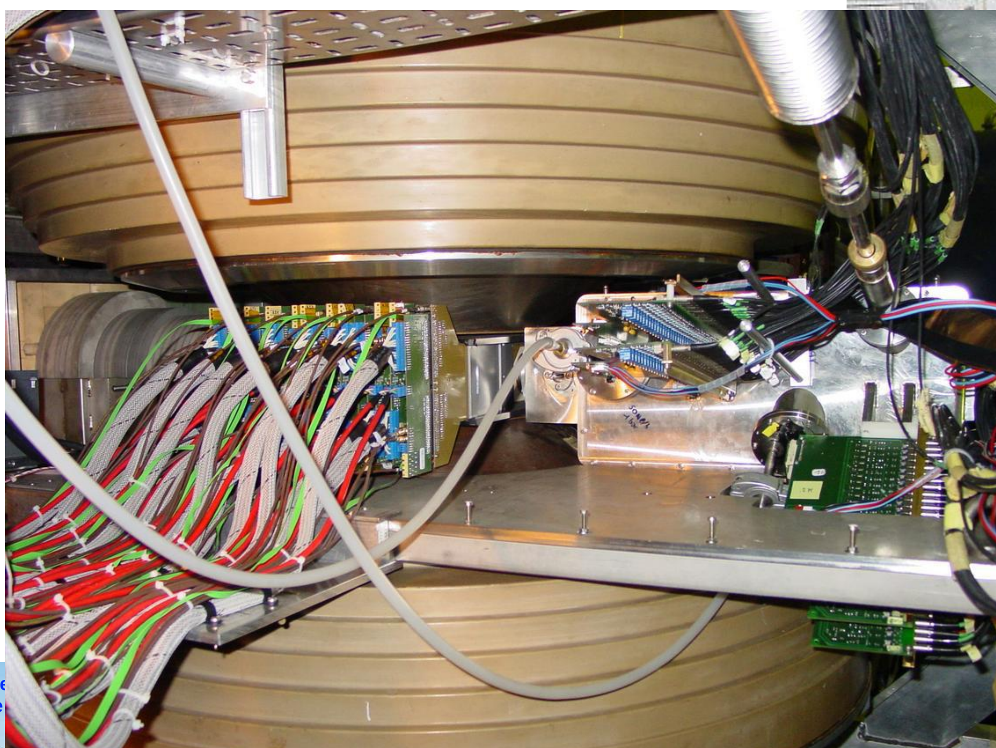
- WHAT IS NEEDED FOR PROGRESS?
  - STATISTICS
  - MASS RESOLUTION

How to overcome these limitations

- more statistics
  - run forever → not an option
  - higher interaction rate
    - higher beam intensity
    - thicker target
  - needed to tolerate this
    - extremely selective hardware trigger
    - reduced sensitivity to secondary interactions, e.g. in target
  - → can’t be done with dielectrons as a probe, but dimuons are just fine!
- better mass resolution
  - stronger magnetic field
  - detectors with better position resolution
  - → silicon tracker embedded in strong magnetic field!

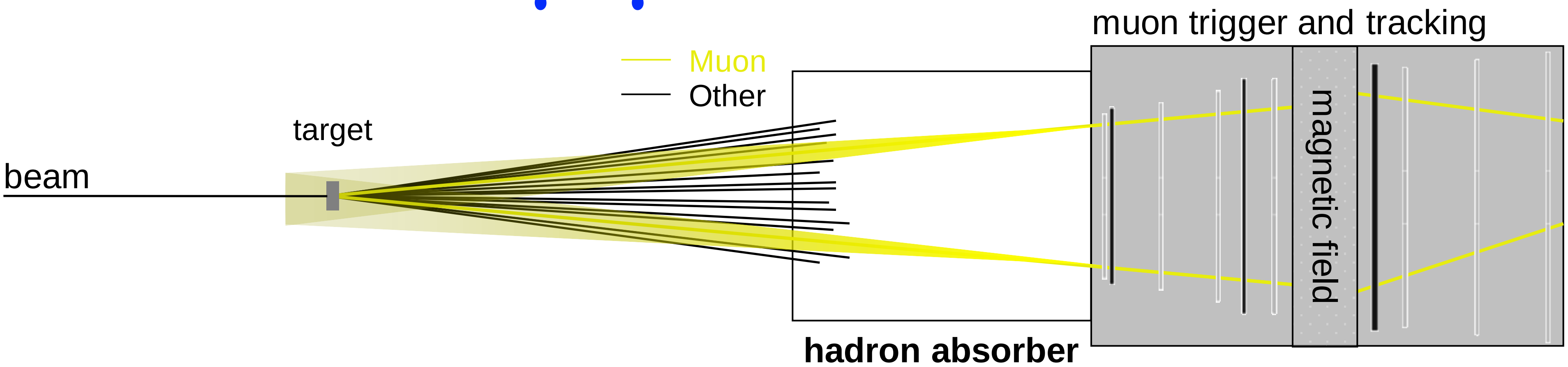
The NA60 experiment

- a huge hadron absorber and muon spectrometer (and trigger!)



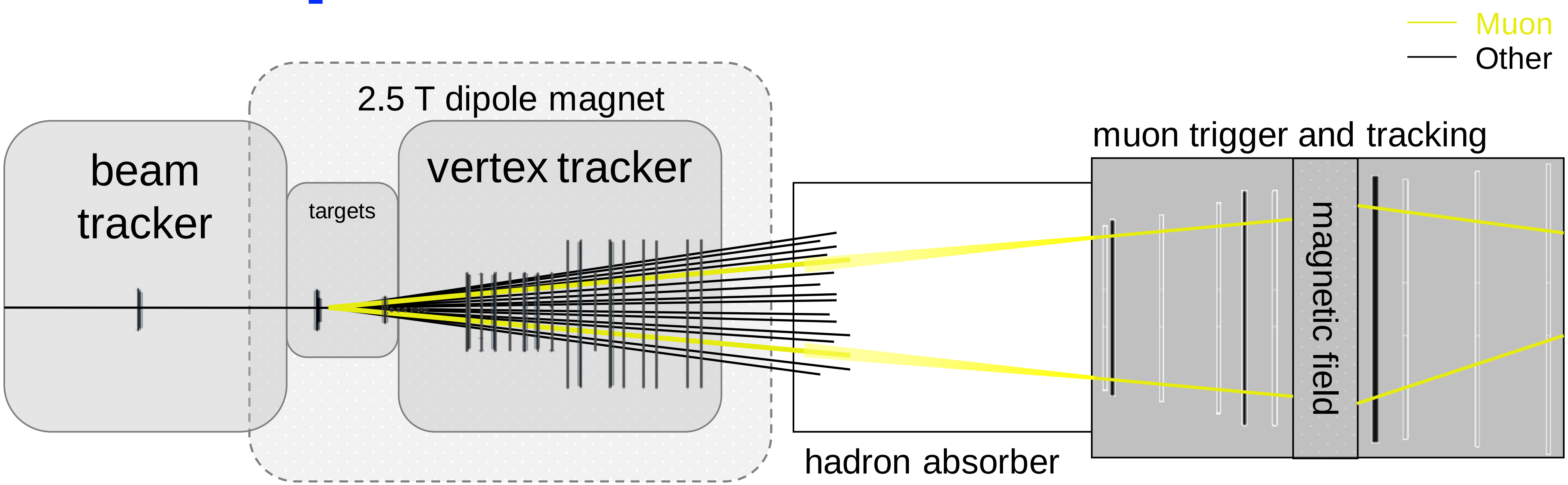
- and a tiny, high resolution, radiation hard vertex spectrometer

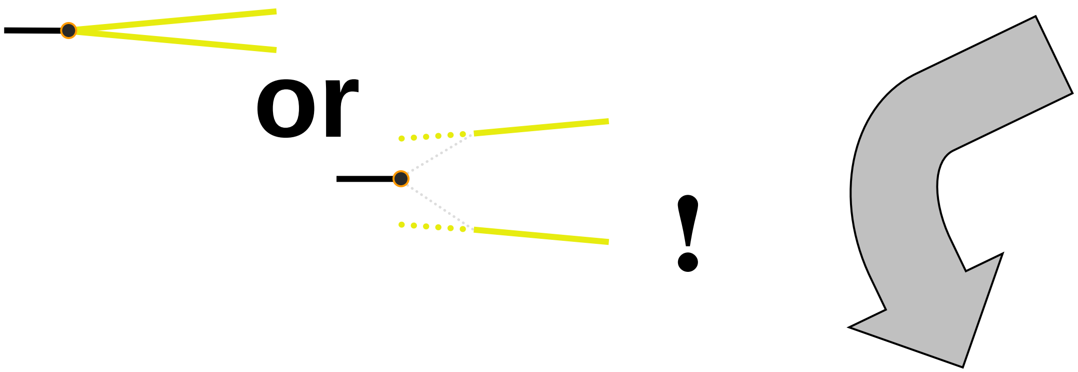
Standard $\mu^+\mu^-$ detection: NA50



- **thick hadron absorber to reject hadronic background**
- **trigger system based on fast detectors to select muon candidates (1 in 10^4 PbPb collisions at SPS energy)**
- **muon tracks reconstructed by a spectrometer (tracking detectors+magnetic field)**
- **extrapolate muon tracks back to the target taking into account multiple scattering and energy loss, but …**
  - **poor reconstruction of interaction vertex (σ_z ~10 cm)**
  - **poor mass resolution (80 MeV at the ϕ)**

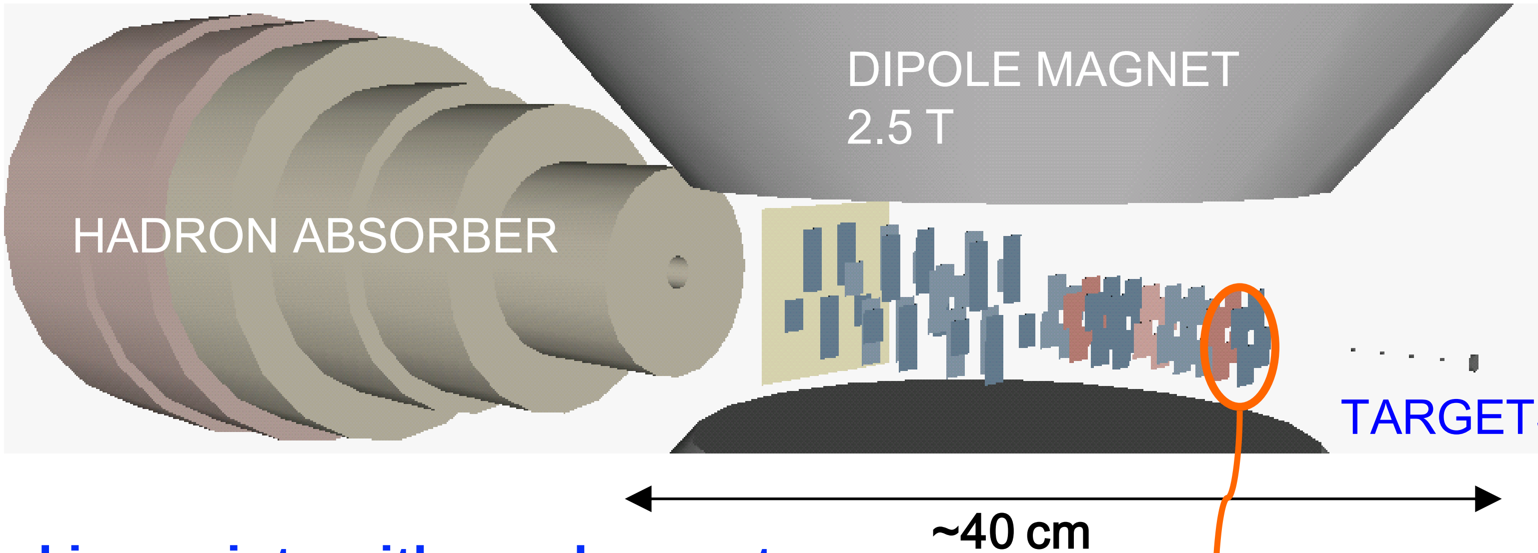
A step forward: the NA60 case



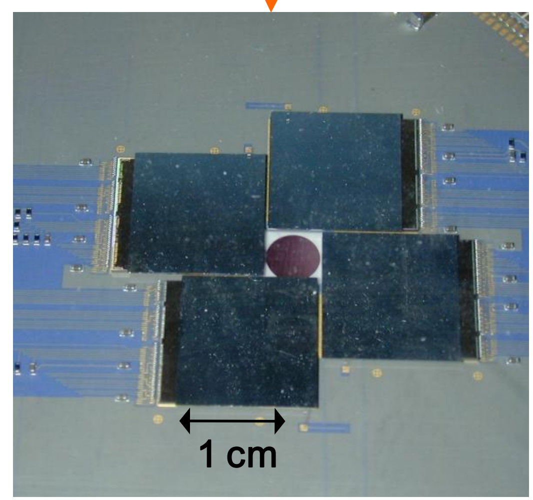


- origin of muons can be determined accurately
- improved dimuon mass resolution

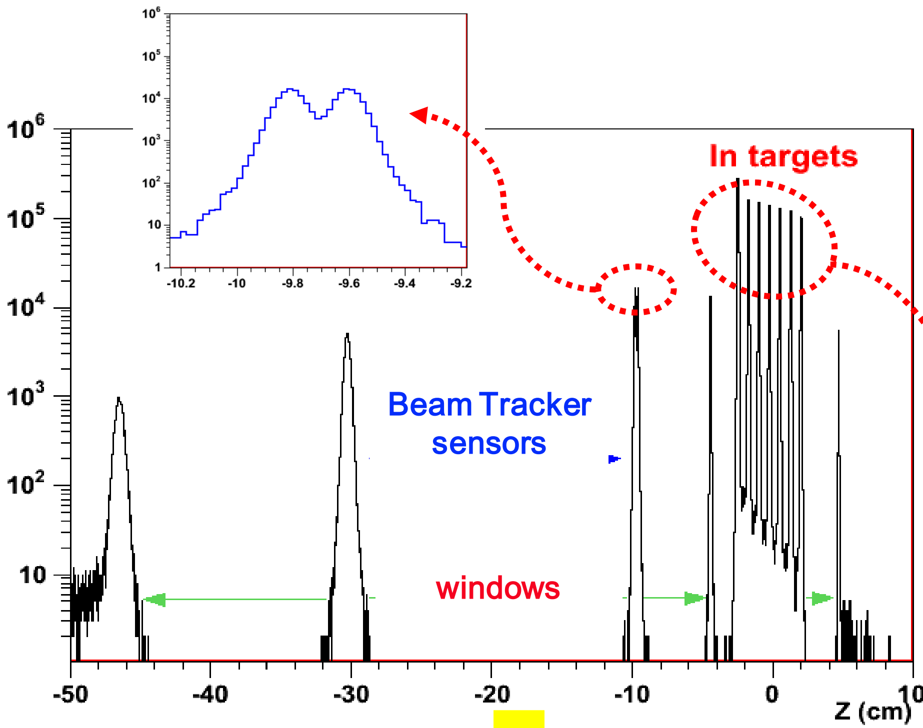
The NA60 pixel vertex spectrometer

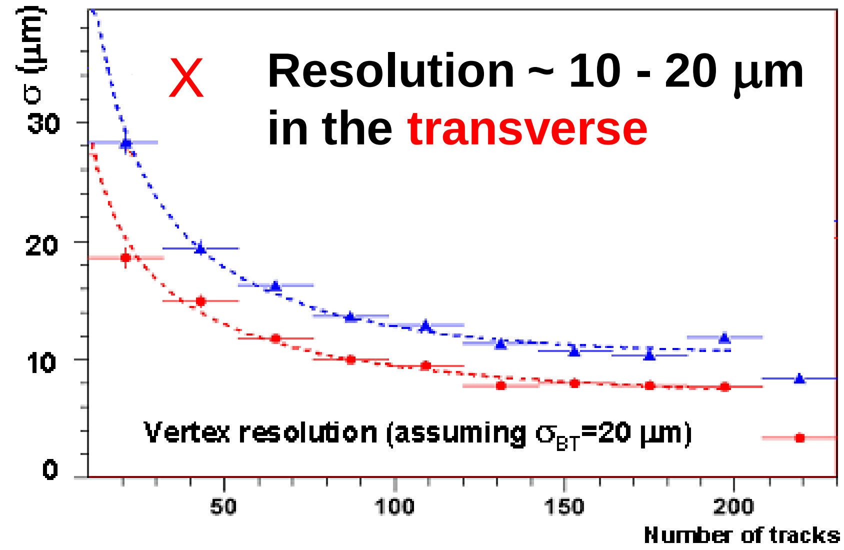


- **12 tracking points with good acceptance**
  - **8 small 4-chip planes**
  - **8 large 8-chip planes in 4 tracking stations**
- **~3% X_0 per plane**
  - **750 μm Si readout chip**
  - **300 μm Si sensor**
  - **ceramic hybrid**
- **800000 readout channels in 96 pixel assemblies**

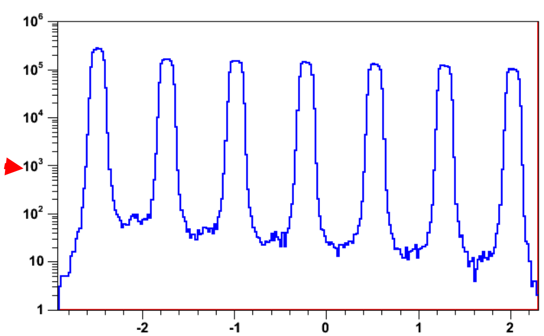


Vertexing in NA60





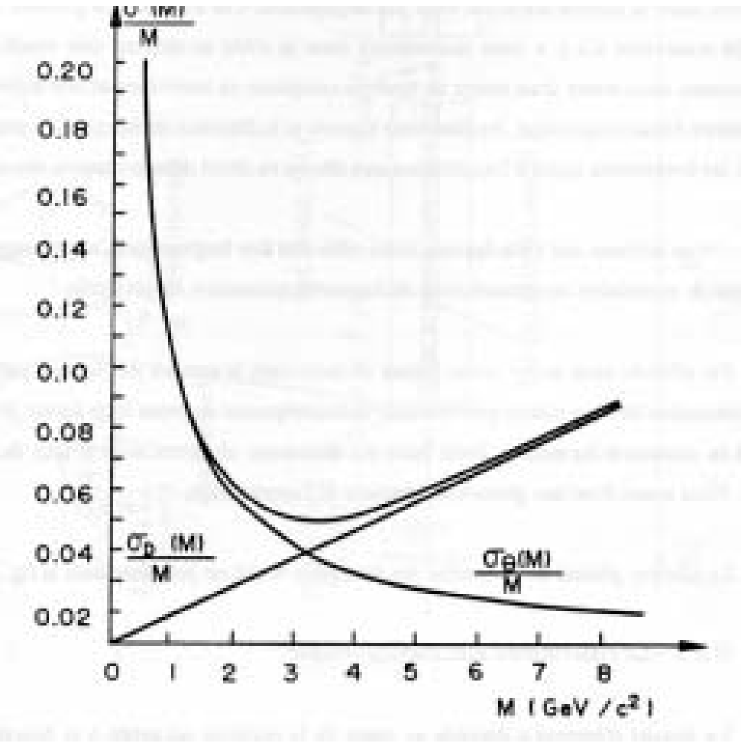
σ_z ~ 200 μm along the beam direction
Good vertex identification with ≥ 4 tracks



Extremely clean target identification (Log scale!)

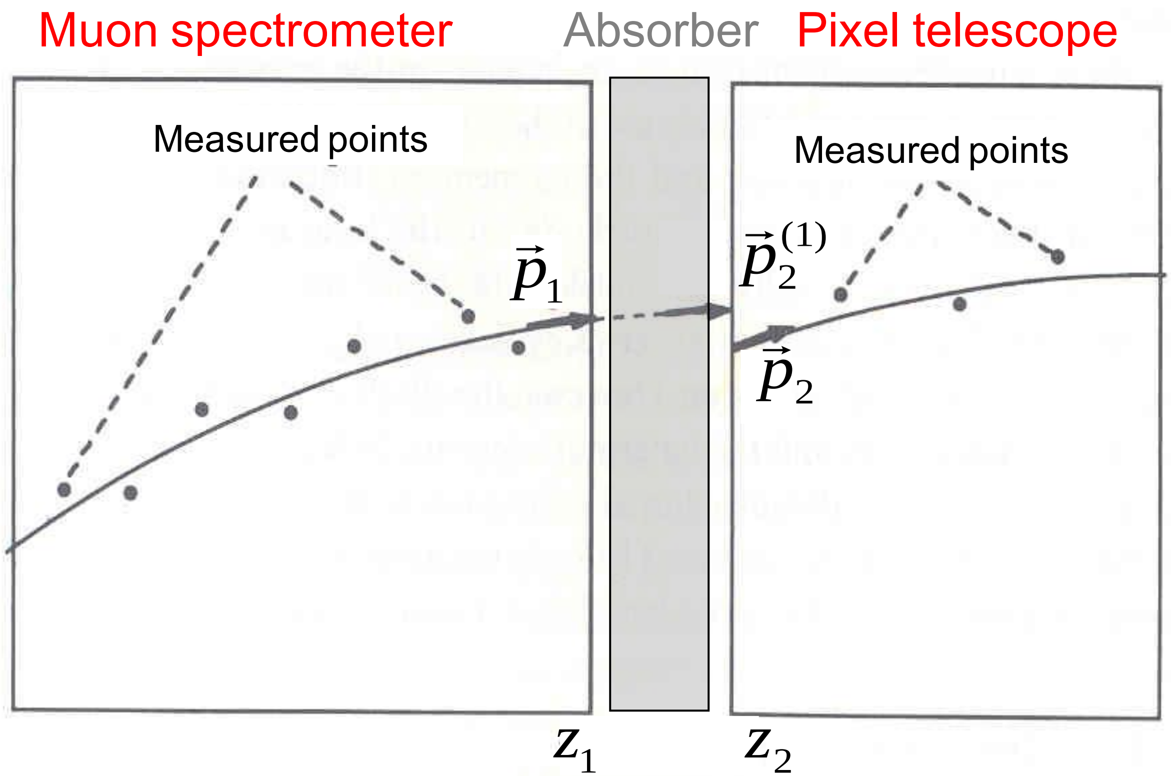
Contributions to mass resolution

- two components
  - multiple scattering in the hadron absorber
    - dominant at low momentum
  - tracking accuracy
    - dominant at high momentum
- high mass dimuons (~3 GeV/c^2)
  - absorber doesn't matter
- low mass dimuons (~1 GeV/c^2)
  - absorber is crucial
  - momentum measurement before the absorber promises huge improvement in mass resolution



- → track matching is critical for high resolution low mass dimuon measurements!

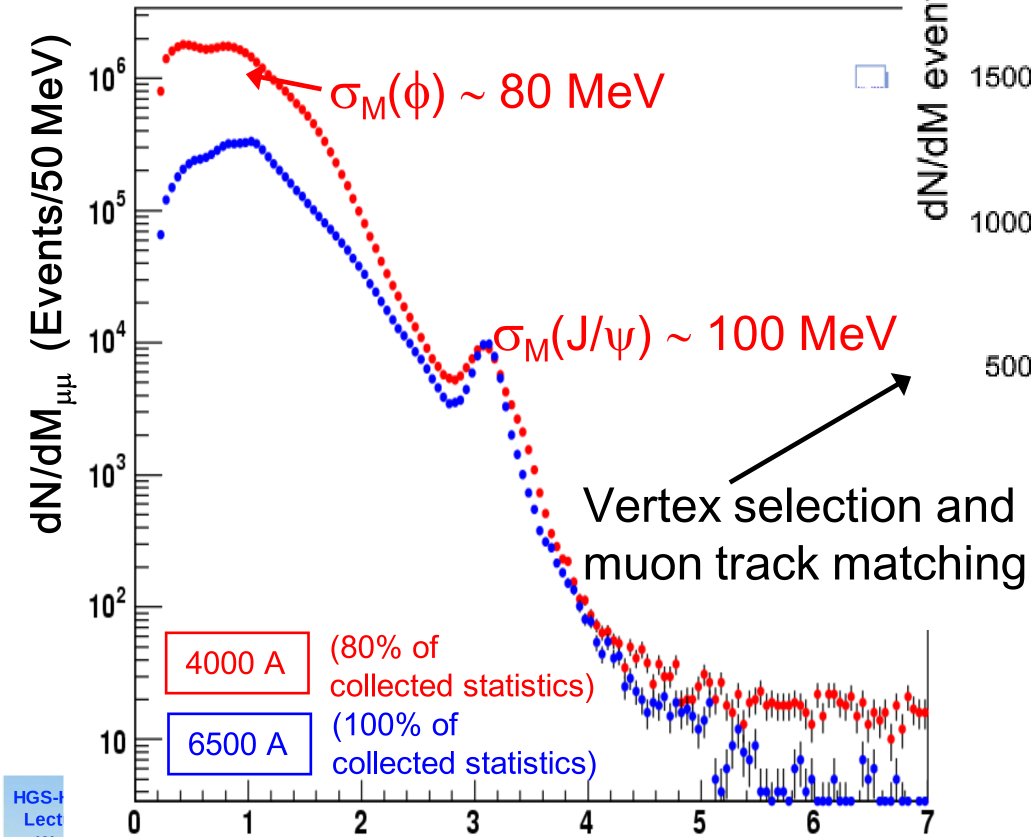
Muon track matching

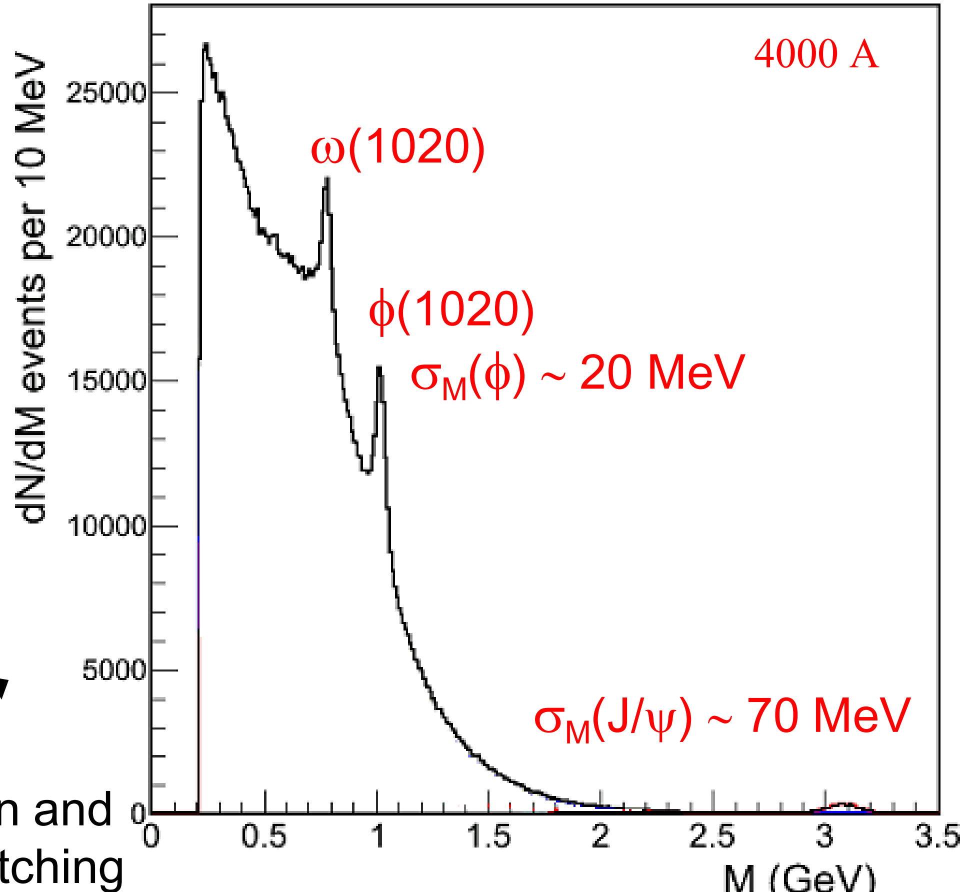


- track matching has to be done in
  - position space
  - momentum space
- to be most effective
- → the pixel telescope has to be a spectrometer!

Improvement in mass resolution

- unlike sign dimuon mass distribution before quality cuts and without muon track matching

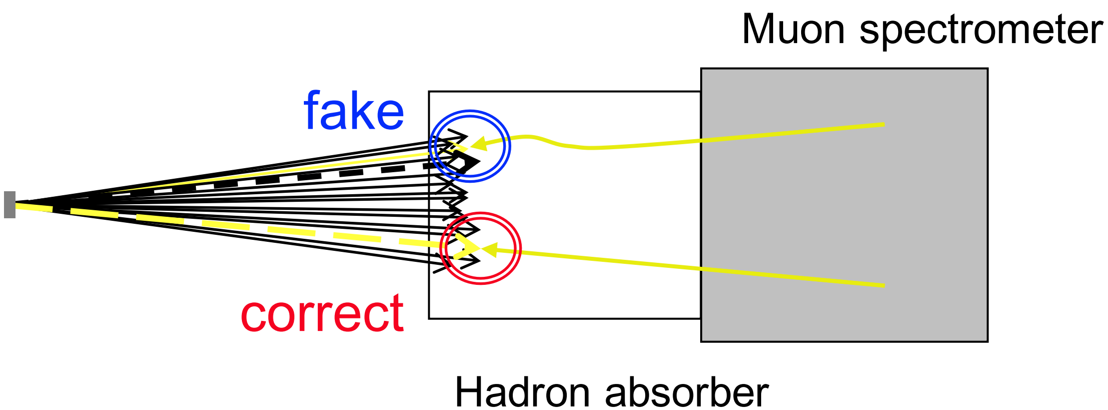


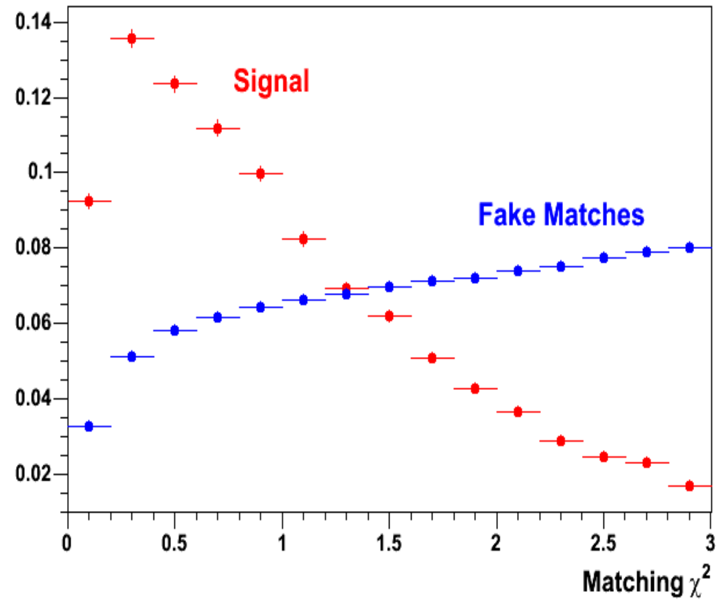


- drastic improvement in mass resolution
- still a large unphysical background

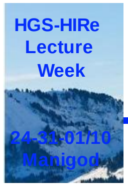
Nothing is perfect: fake matches

- fake match: μ matched to wrong track in pixel telescope
  - important in high multiplicity events



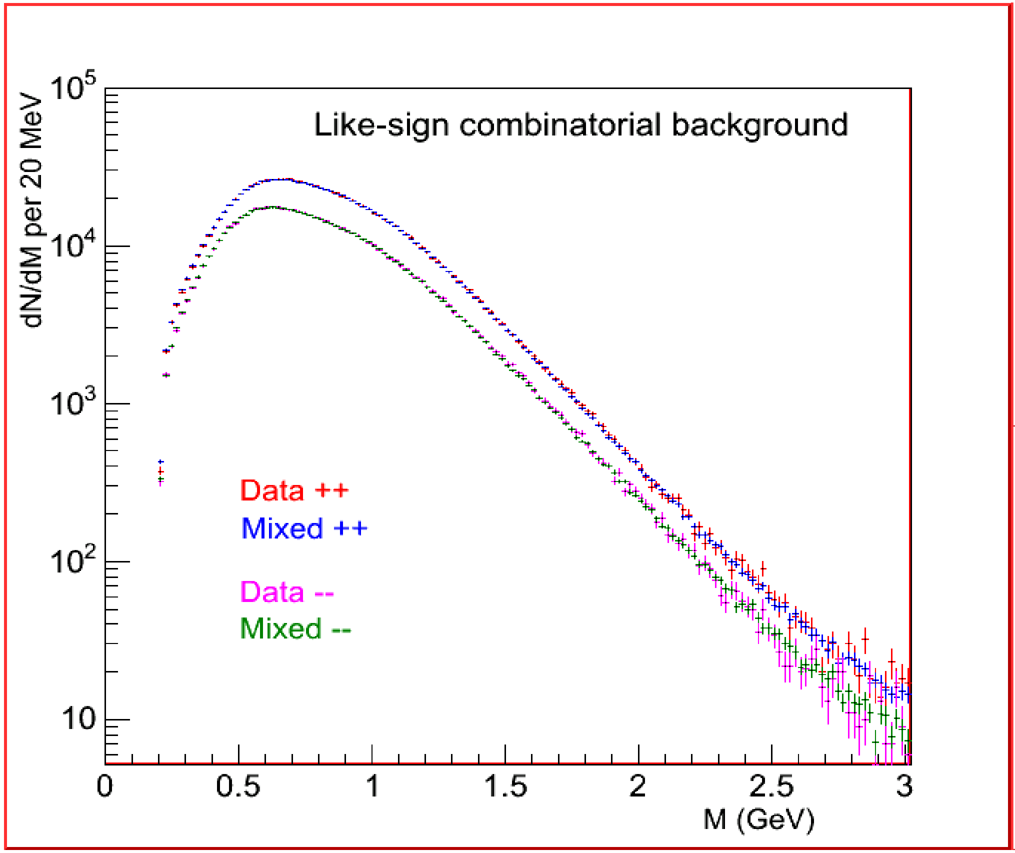


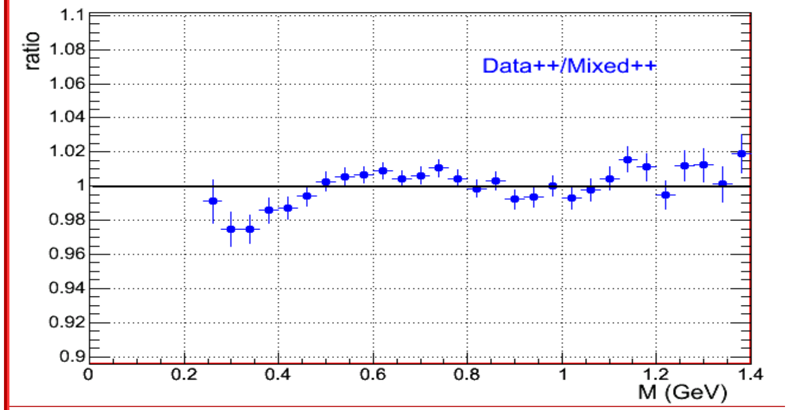
- how to deal with fake matches
  - keep track with best χ^2 (but is is right?)
  - embedding of muon tracks into other event
  - identify fake matches and determine the fraction of these relative to correct matches as function of
    - centrality
    - transverse momentum

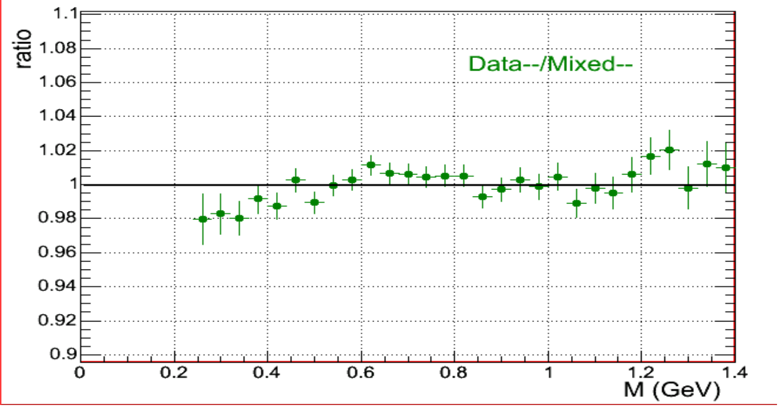


Event mixing: like-sign pairs

- compare measured and mixed like-sign pairs





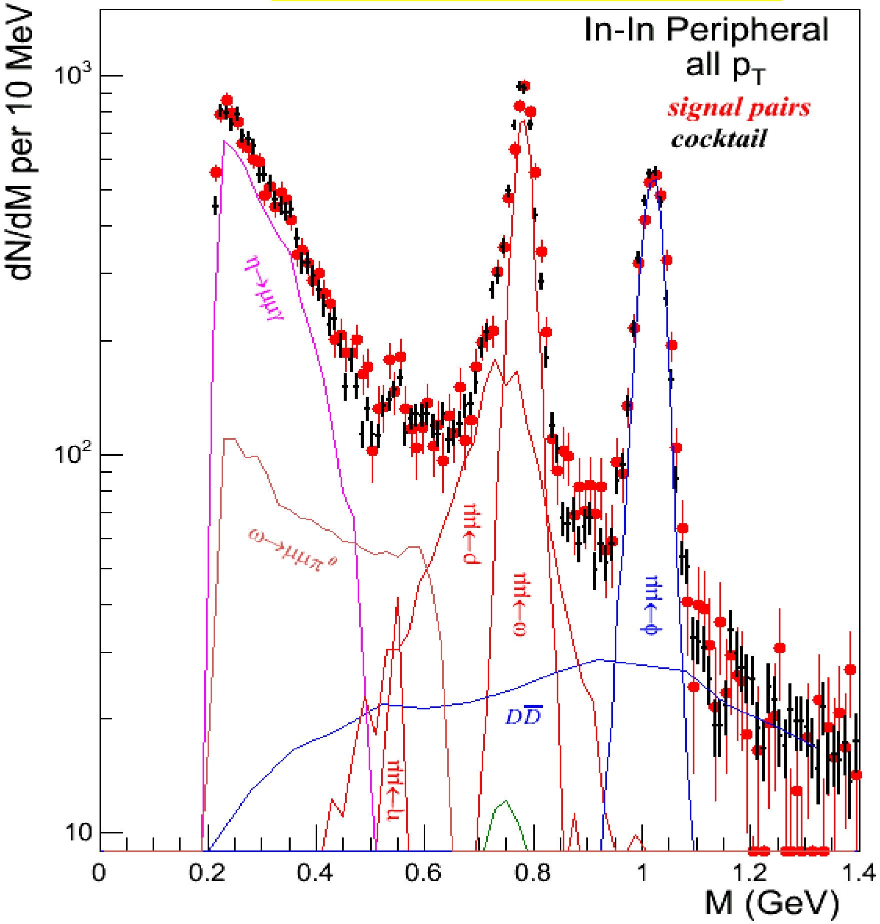


- accuracy in NA60: ~1% over the full mass range

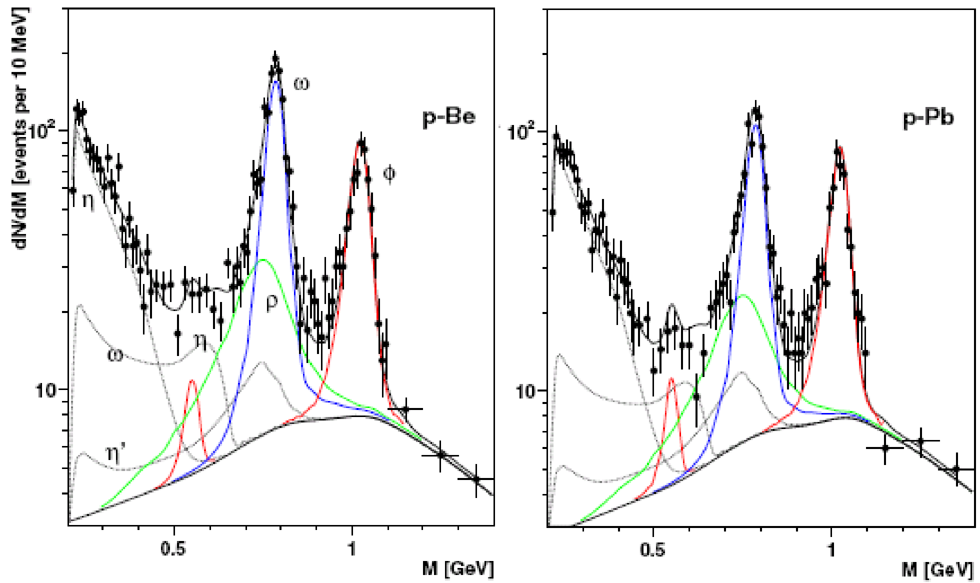
LMR data: peripheral (N_{ch}<30) In-In collisions

Well described by meson decay 'cocktail': η, η', ρ, ω, f and DD contributions (Genesis generator developed within CERES and adapted for dimuons by NA60).

Eur.Phys.J.C 49 (2007) 235



Eur.Phys.J.C 43 (2005) 407



Similar cocktail describes NA60 p-Be,In,Pb 400 GeV data

EM transition form-factors for $\omega \to \mu^+\mu^-\pi^0$ and $\eta \to \mu^+\mu^-\gamma$
peripheral NA60 InIn data

hep-ph/0902.2547, submitted to PLB

Acceptance-corrected data (after subtraction of η,ω and φ peaks)
fitted by three contributions:

$$\frac{d\Gamma(\eta\to\mu^+\mu^-\gamma)}{dm_{\mu\mu}^2}=\frac{2\alpha}{3\pi}\frac{\Gamma(\eta\to\gamma\gamma)}{m_{\mu\mu}^2}\left(1-\frac{m_{\mu\mu}^2}{m_\eta^2}\right)^3\left(1+\frac{2m_\mu^2}{m_{\mu\mu}^2}\right)\left(1-\frac{4m_\mu^2}{m_{\mu\mu}^2}\right)^{1/2}\times\left|F_\eta(m_{\mu\mu}^2)\right|^2$$

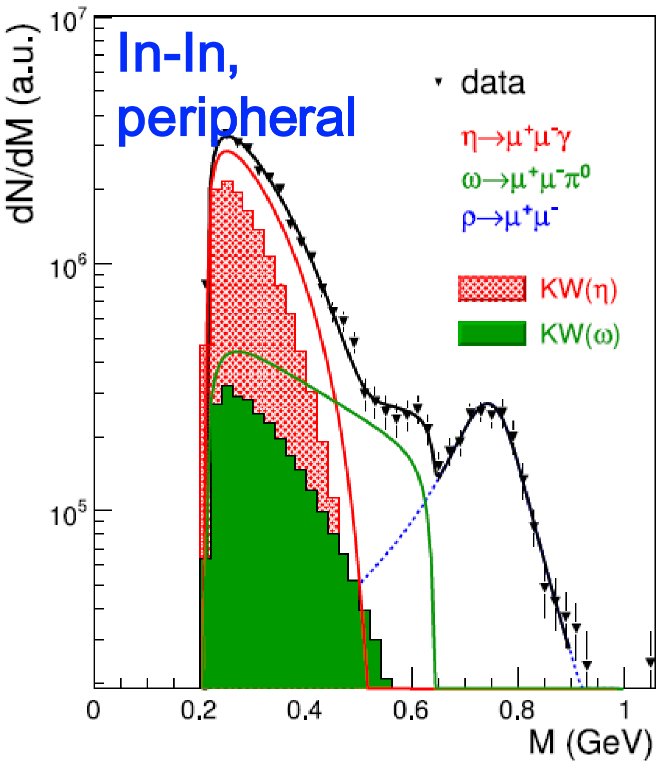
$$\frac{d\Gamma(\omega\to\mu^+\mu^-\pi^0)}{dm_{\mu\mu}^2}=\frac{\alpha}{3\pi}\frac{\Gamma(\omega\to\pi^0\gamma)}{m_{\mu\mu}^2}\left(1+\frac{2m_\mu^2}{m_{\mu\mu}^2}\right)\left(1-\frac{4m_\mu^2}{m_{\mu\mu}^2}\right)^{1/2}\left[\left(1+\frac{m_{\mu\mu}^2}{m_\omega^2-m_{\pi^0}^2}\right)^2-\frac{4m_\omega^2m_{\mu\mu}^2}{m_\omega^2-m_{\pi^0}^2}\right]^{3/2}\times\left|F_\omega(m_{\mu\mu}^2)\right|^2$$

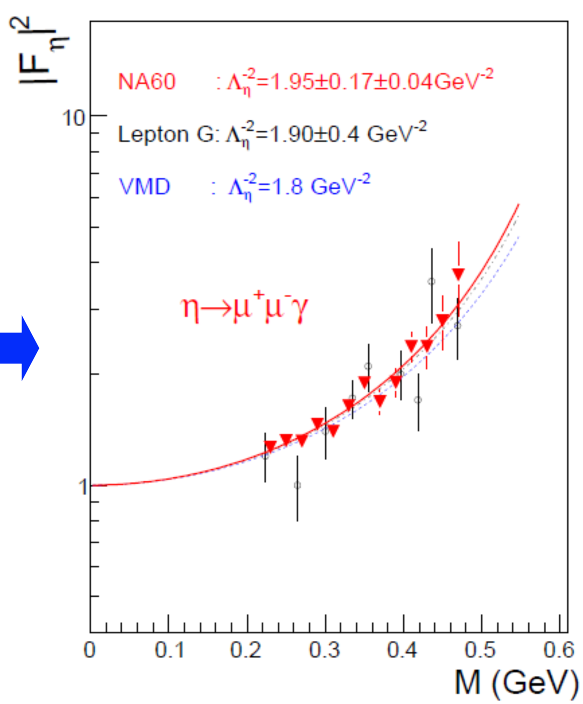
$$\frac{dR(\rho\to\mu^+\mu^-)}{dM}=\frac{\alpha^2m_\rho^4}{3(2\pi)^4}\frac{\left(1-\frac{4m_\pi^2}{M^2}\right)^{3/2}\left(1-\frac{4m_\mu^2}{M^2}\right)^{1/2}\left(1+\frac{2m_\mu^2}{M^2}\right)}{\left(M^2-m_\rho^2\right)^2+M^2\Gamma^2}(2\pi MT)^{3/2}e^{-\frac{M}{T}}$$

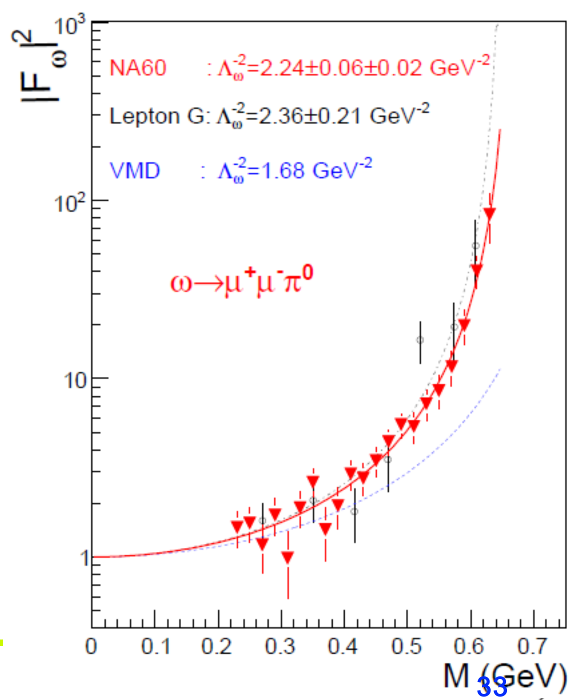
pole approximation:

$$\left|F(m_{\mu\mu}^2)\right|^2=\left(1-m_{\mu\mu}^2/\Lambda^2\right)^{-2}$$

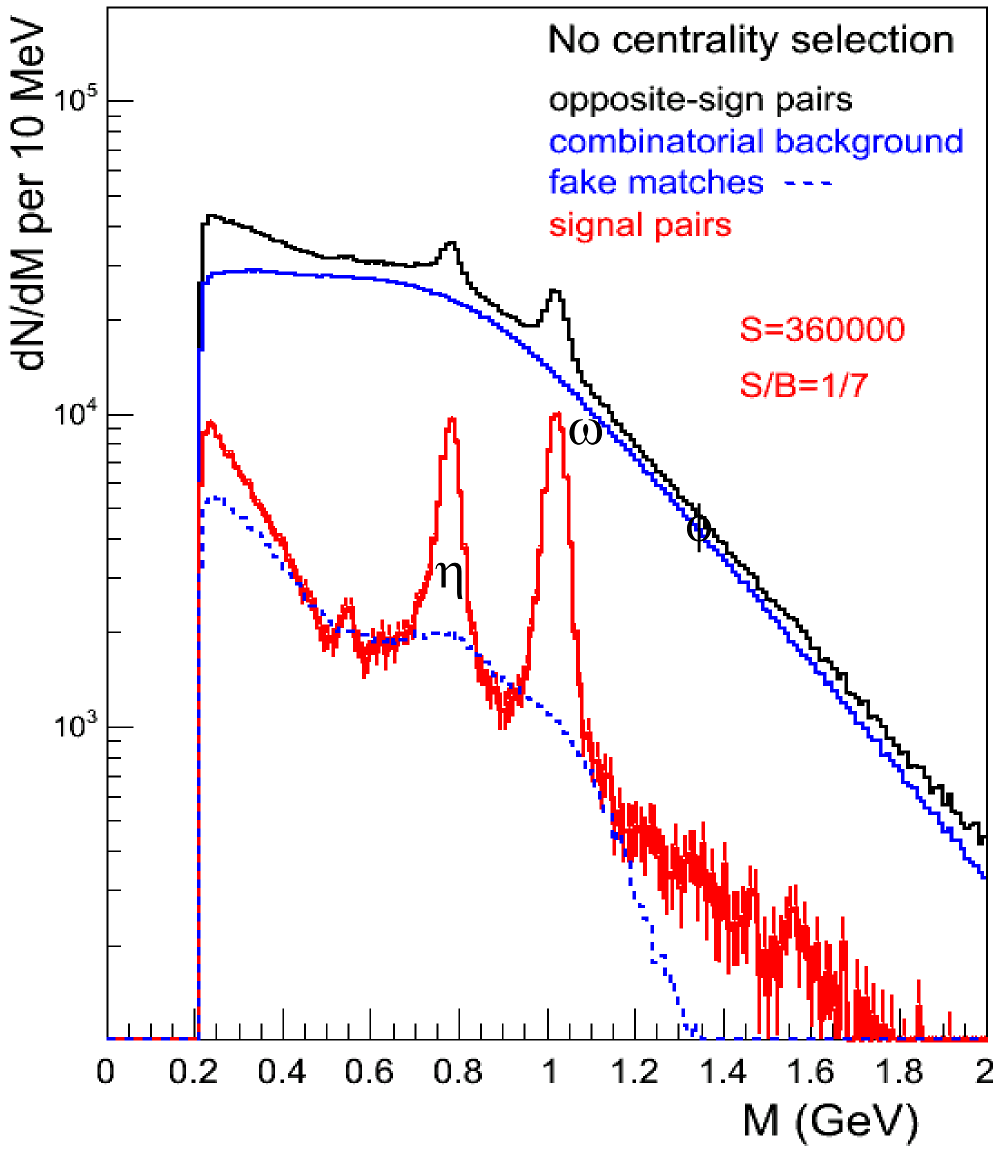
- Confirmed anomaly of F_ω wrt the VDM prediction.
- Improved errors wrt the Lepton-G results.
- Removes FF ambiguity in the 'cocktail'







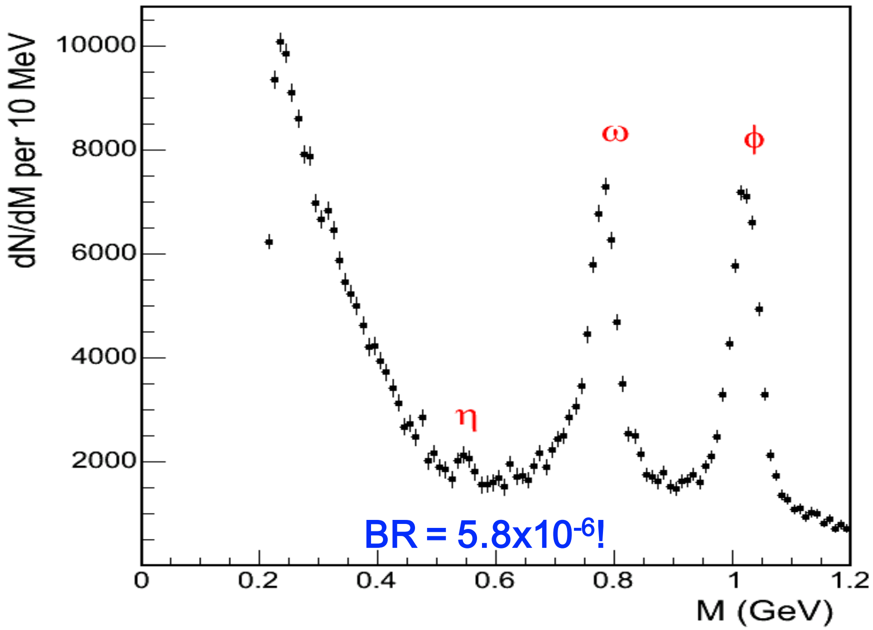
LMR data: Min.Bias In-In collisions



Low Mass Region

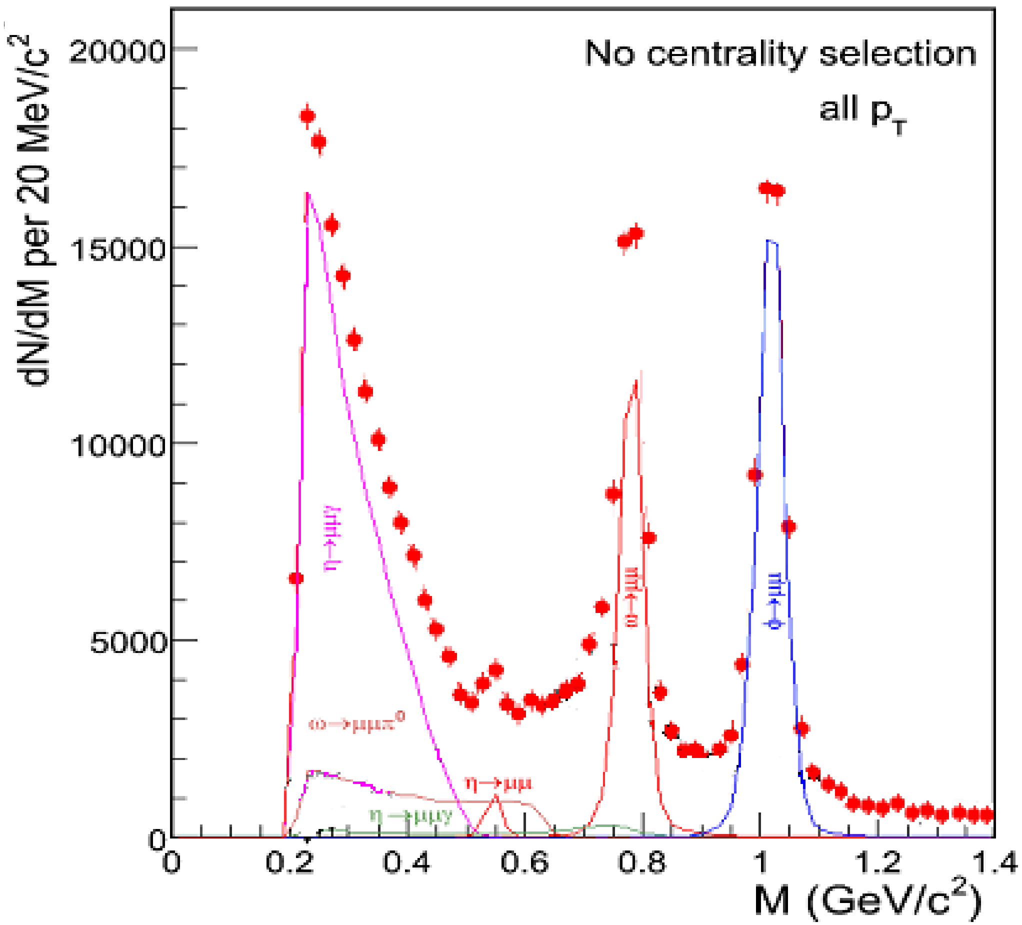
Improvement

- Statistics
- Resolution



Cocktail subtraction (without ρ)

- how to nail down an unknown source?
- → try to find excess above cocktail without fit constraints



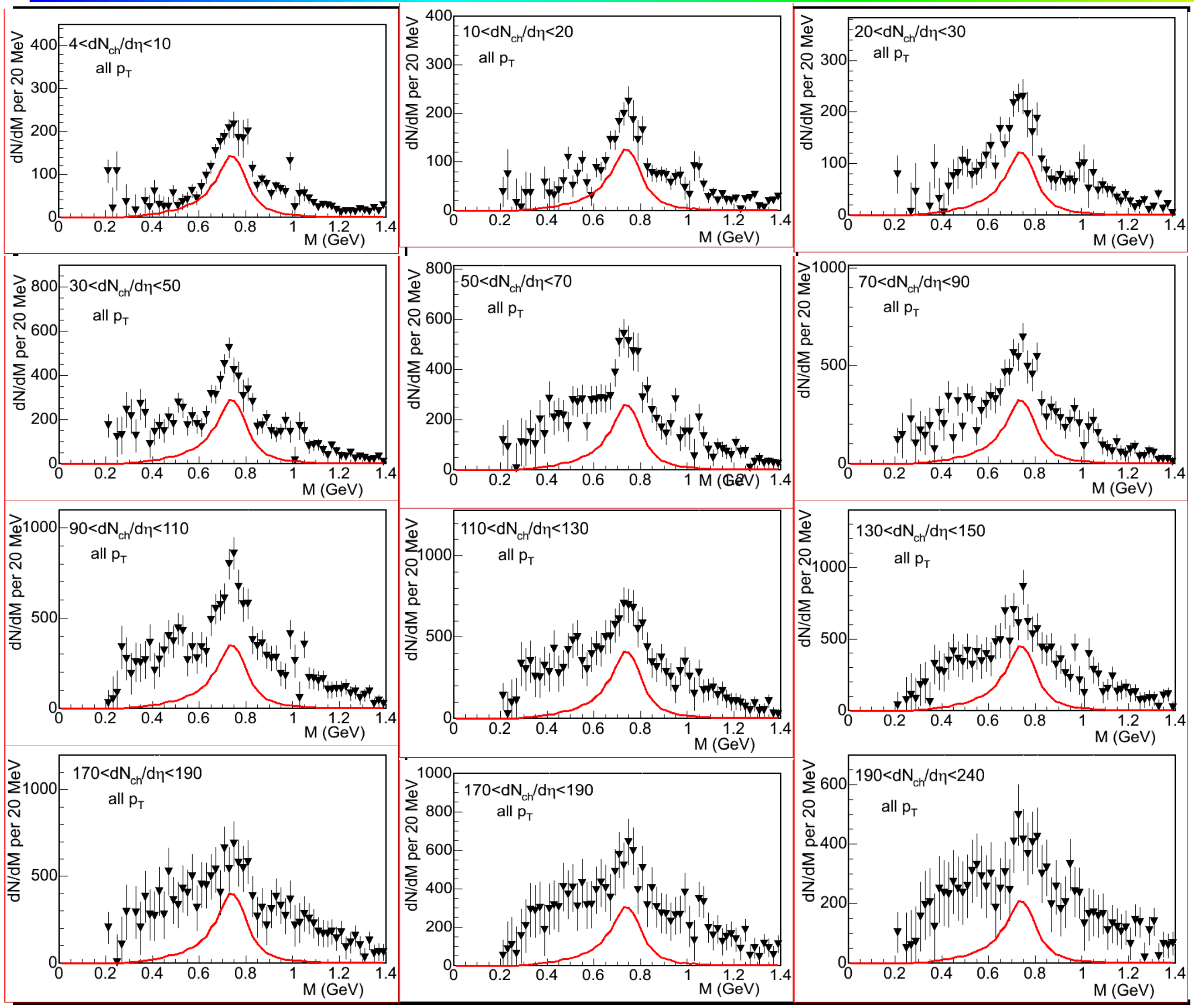
- ω and φ: fix yields such as to get, after subtraction, a smooth underlying continuum

- η :

  (▼) set upper limit, defined by "saturating" the measured yield in the mass region close to 0.2 GeV (lower limit for excess).

  (△) use yield measured for p_T > 1.4 GeV/c

Excess versus centrality

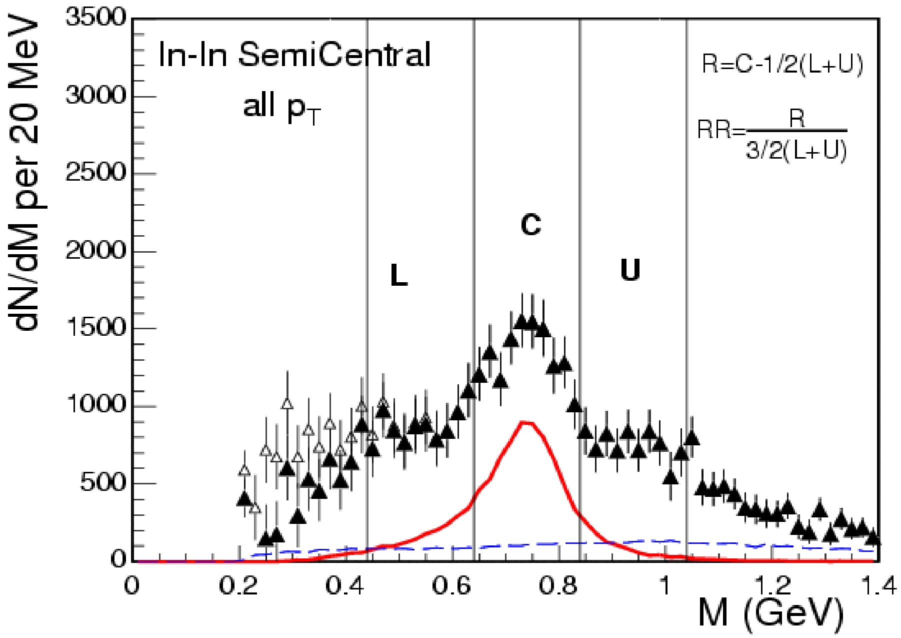


data – cocktail (all p_T)

- No cocktail ρ and no DD subtracted
- Clear excess above the cocktail ρ, centered at the nominal ρ pole and rising with centrality
- Excess even more pronounced at low p_T

Excess shape versus centrality

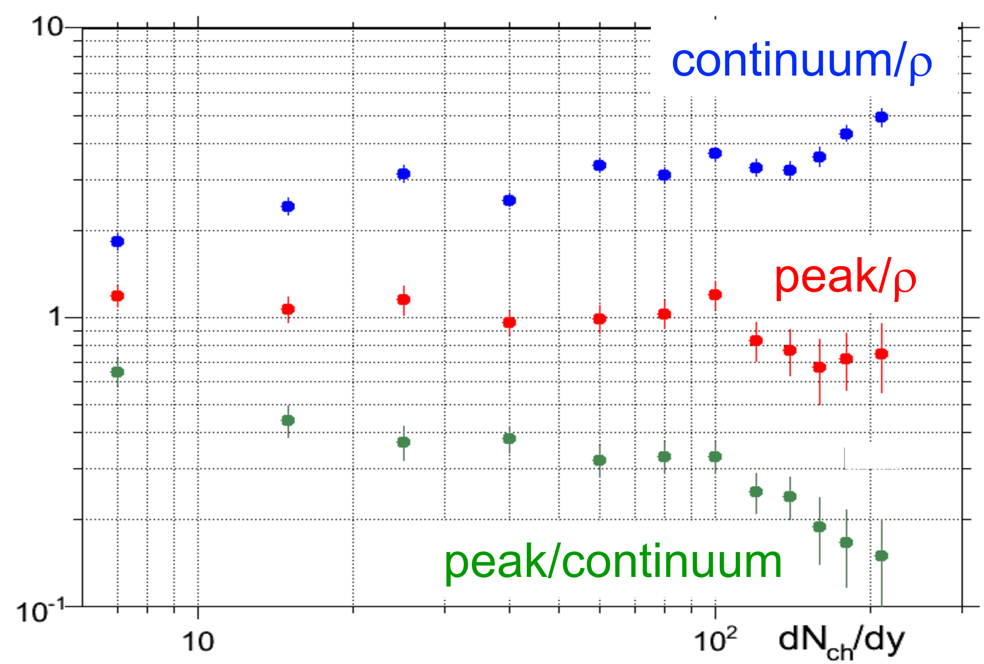
Quantify the peak and the broad symmetric continuum with a mass interval C around the peak (0.64 <M<0.84 GeV) and two equal side bins L, U



continuum = 3/2(L+U)

peak = C-1/2(L+U)

Fine analysis in 12 centrality bins



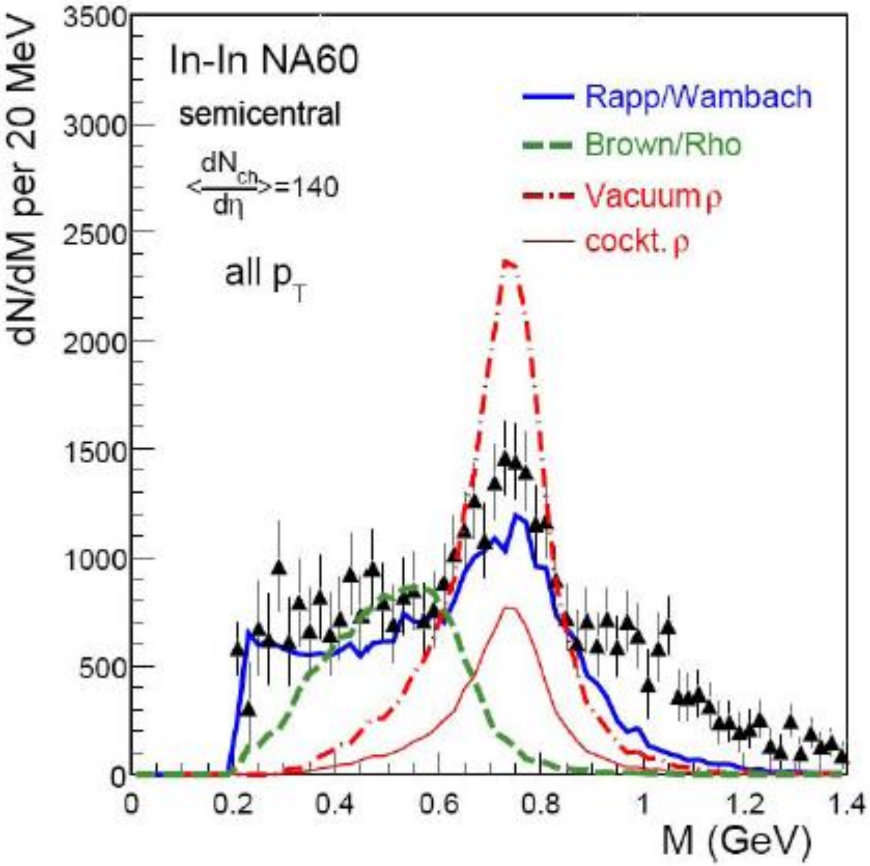
Peak/cocktail ρ drops by a factor ~2 from peripheral to central:

the peak seen is not the cocktail ρ

nontrivial changes of all three variables at dN_{ch}/dy>100 ?

Comparison with prominent models

- Rapp & Wambach
  - hadronic model with strong broadening but no mass shift
- Brown & Rho
  - dropping mass due to dropping chiral condensate

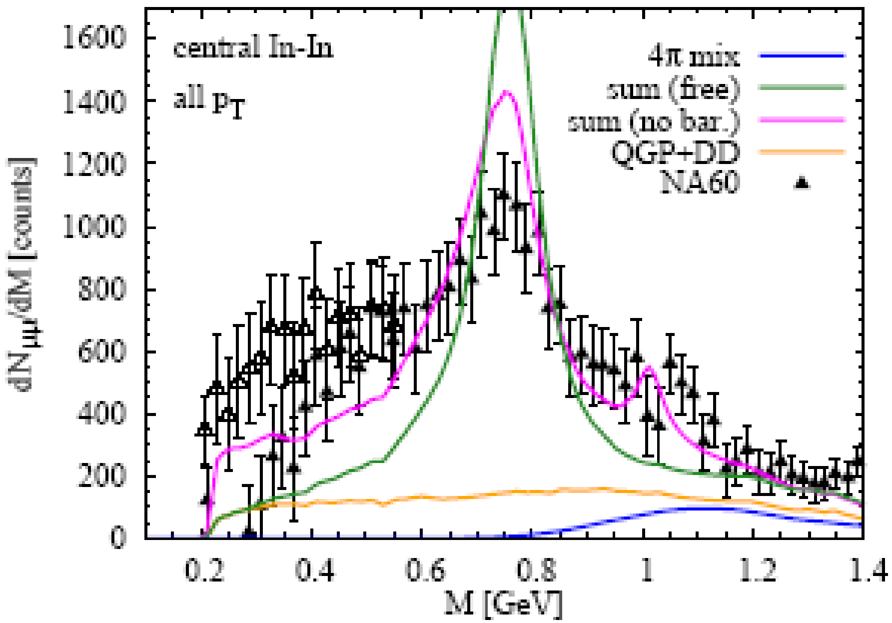


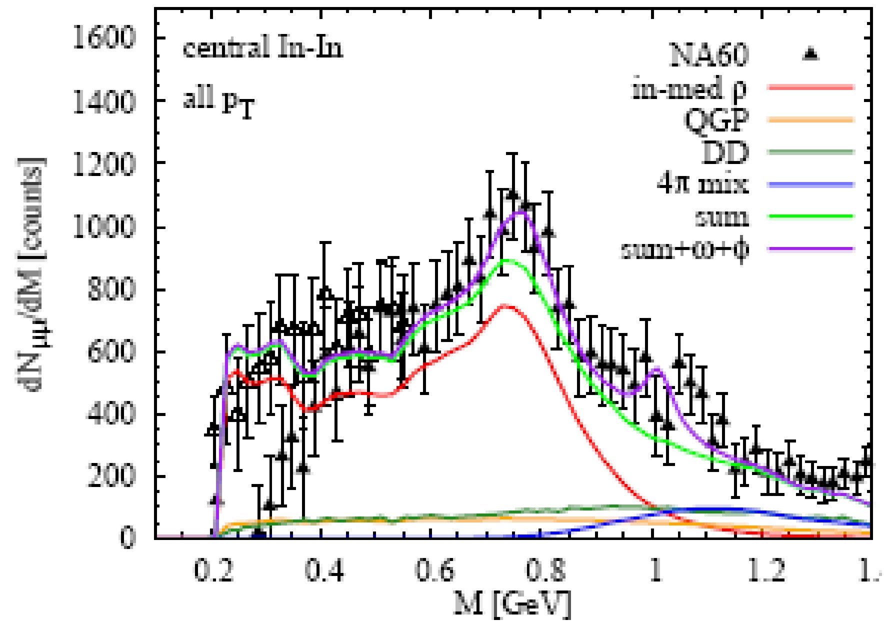
- calculations for all scenarios in In-In for $dN_{ch}/d\eta = 140$ (Rapp et al.)
- spectral functions after acceptance filtering, averaged over space-time and momenta
- Keeping original normalization

data consistent with broadening of ρ (RW), mass shift (BR) not needed

Role of baryons

- improved model calculation (Rapp & van Hees)
  - fireball dynamics
  - 4π processes
  - absolute normalization!
  - towards high p_T the vacuum ρ becomes more important (Rapp/van Hees; Renk/Ruppert)



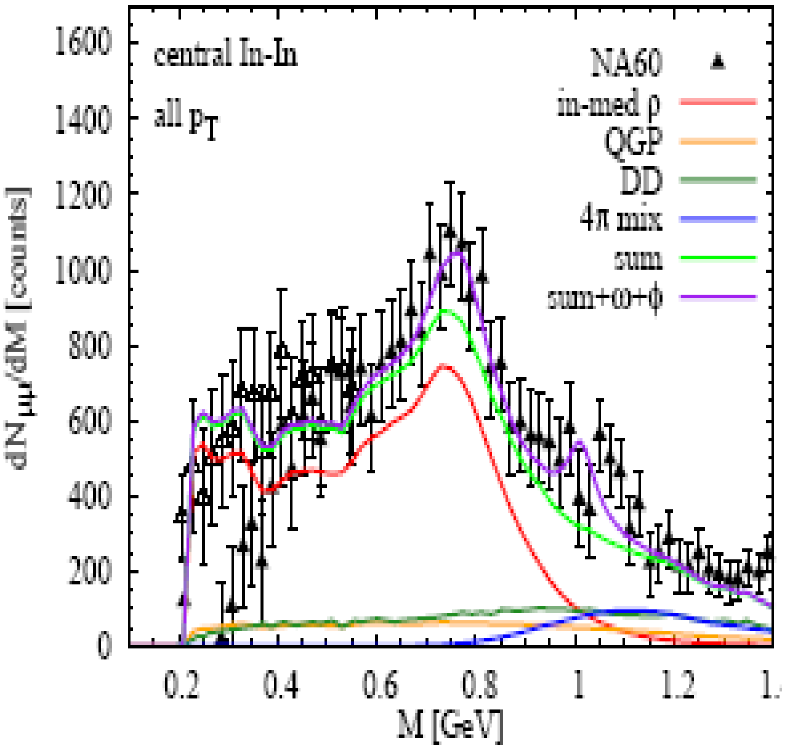


  - without baryons
    - not enough broadening
    - lack of strength below the ρ peak

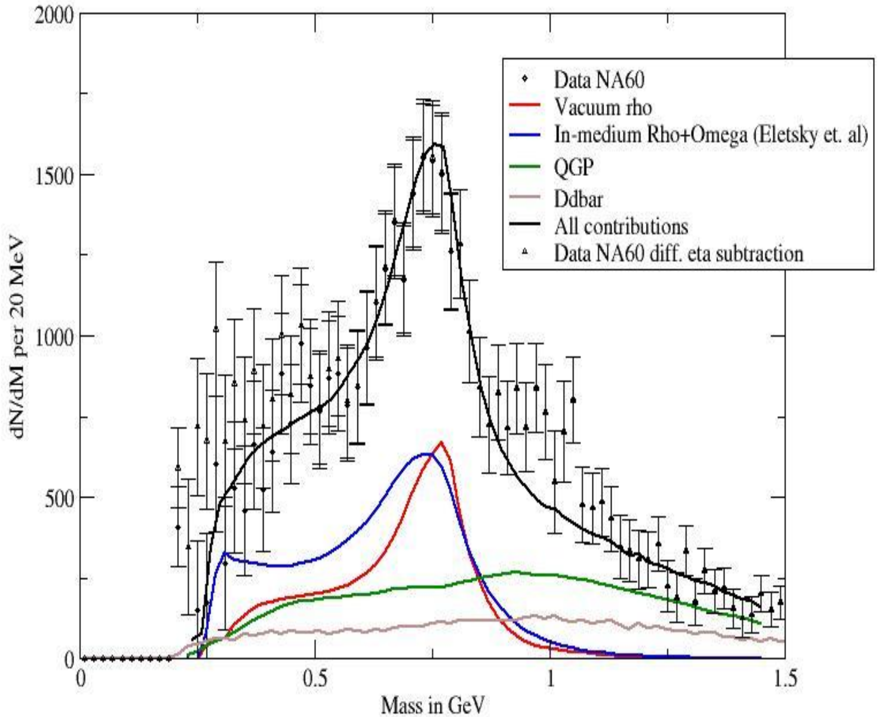
The high mass region (M>1GeV)

- **hadron-parton duality**

Rapp / van Hees



Ruppert / Renk

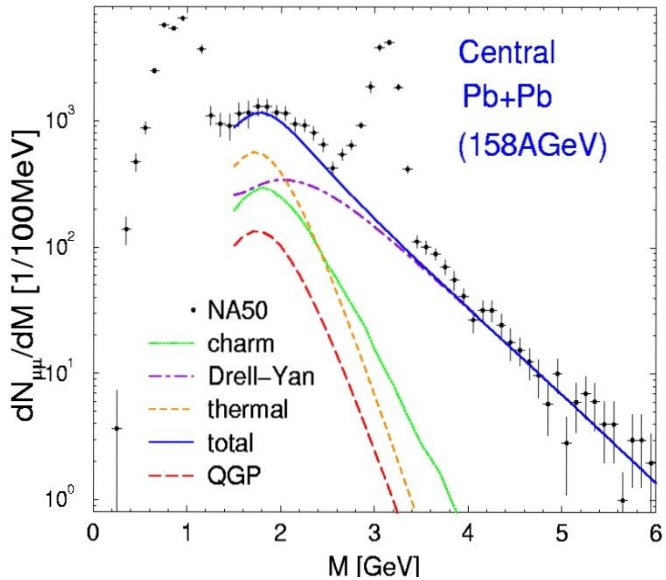


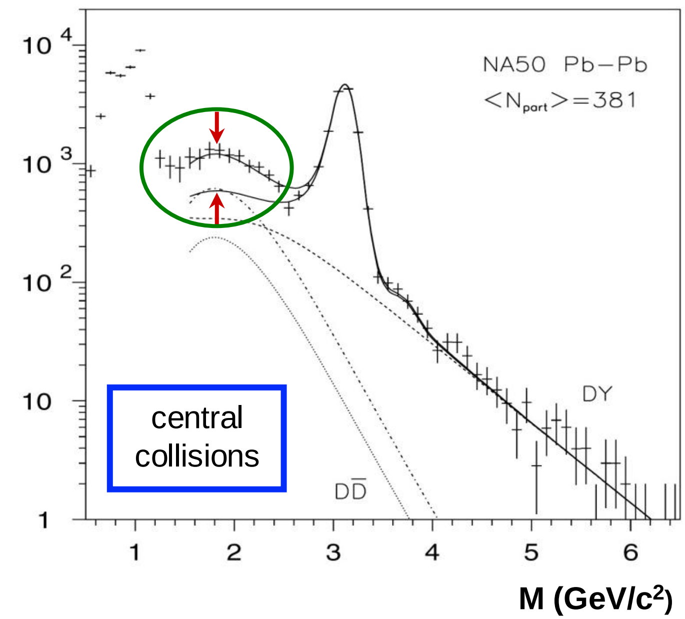
- **dominant at high M**
  - **hadronic processes**
  - **4π ...**

- **dominant at high M**
  - **partonic processes**
  - **mainly qqbar annihilation**

Intermediate mass region (IMR)

- **NA50: excess observed in IMR in central Pb-Pb collisions**
  - **charm enhancement?**
  - **thermal radiation?**

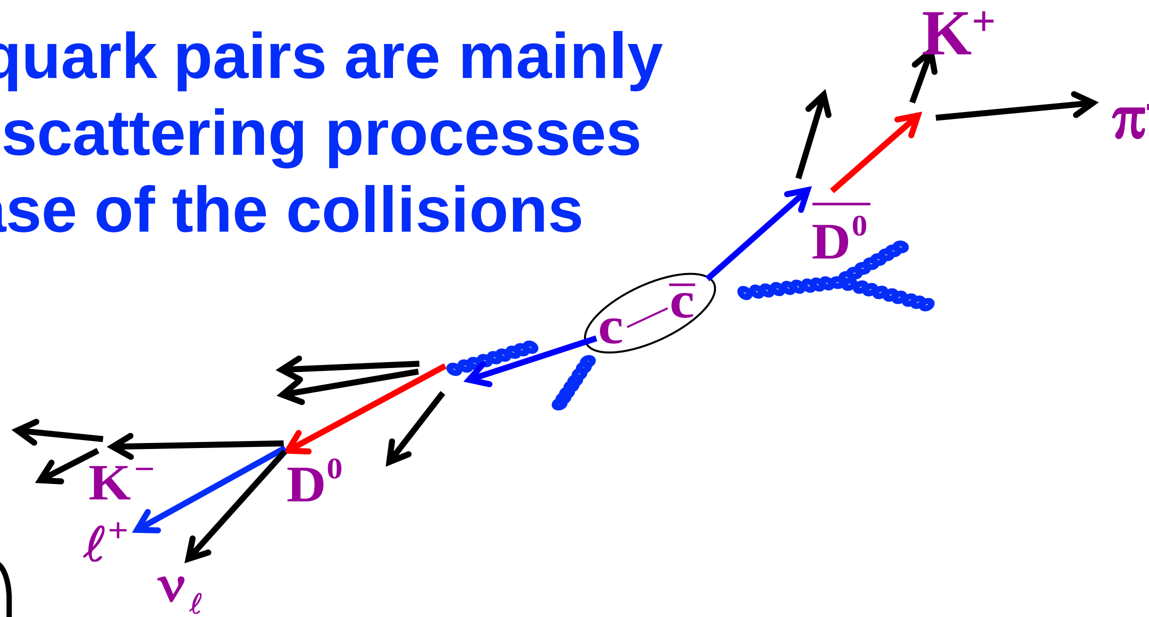


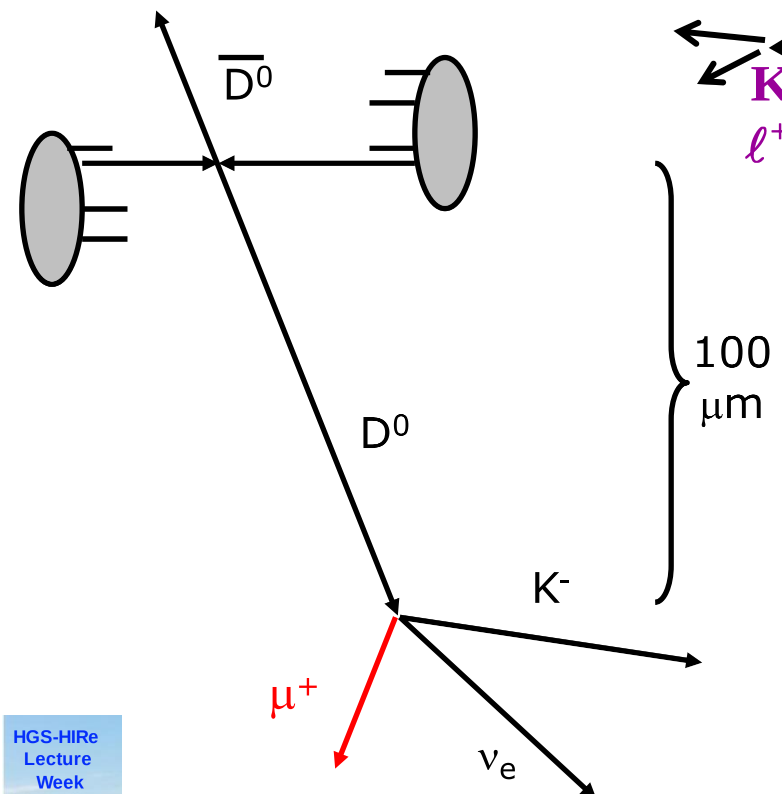


- **answering this question was one of the main motivations for building NA60**

Disentangling the sources in the IMR

- charm quark-antiquark pairs are mainly produced in hard scattering processes in the earliest phase of the collisions

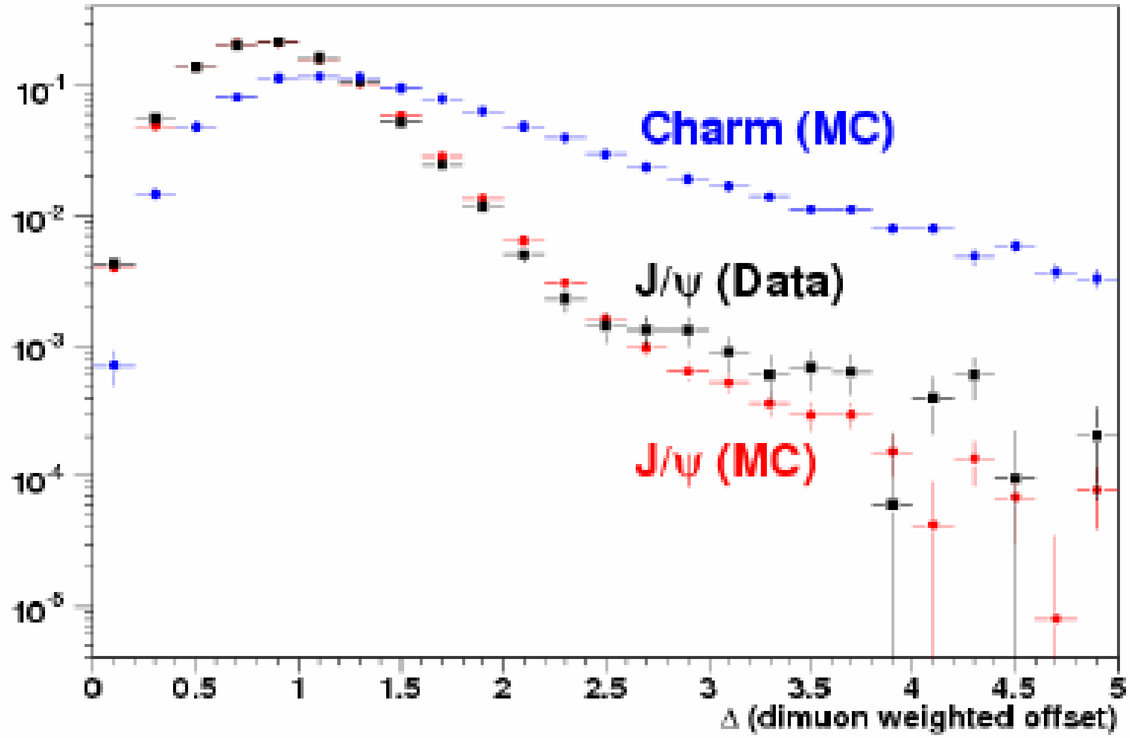




- charmed hadrons are “long” lived → identify the typical offset (“displaced vertex”) of D-meson decays (~100 μm)
- need superb vertexing accuracy (20-30 μm in the transverse plane) → NA60

How well does this work?

- measure for vertex displacement
  - primary vertex resolution
  - momentum dependence of secondary vertex resolutions
  - → "dimuon weighted offset"
- charm decays (D mesons) → displaced
- J/ψ → prompt
- vertex tracking is well under control!



IMR excess: enhanced charm?

- approach
  - fix the prompt contribution to the expected Drell-Yan yield
  - check whether the offset distribution is consistent with charm

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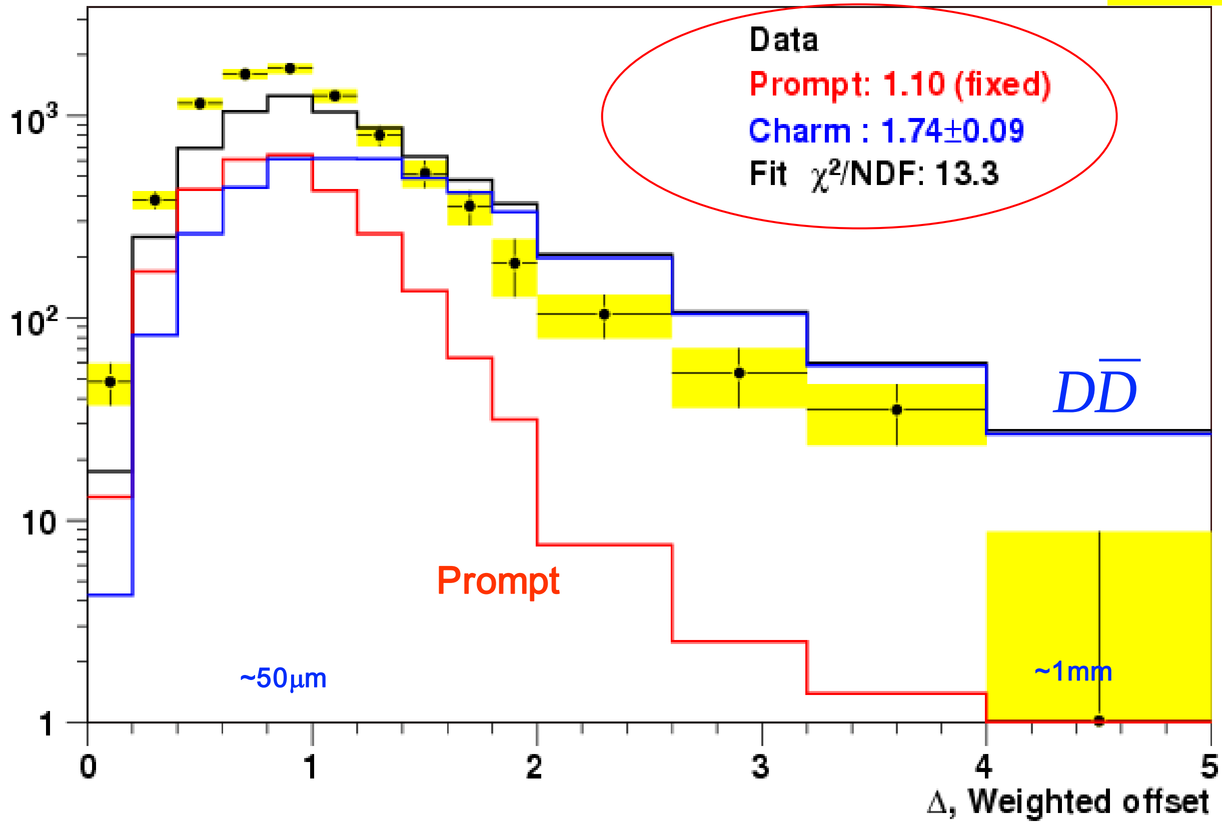
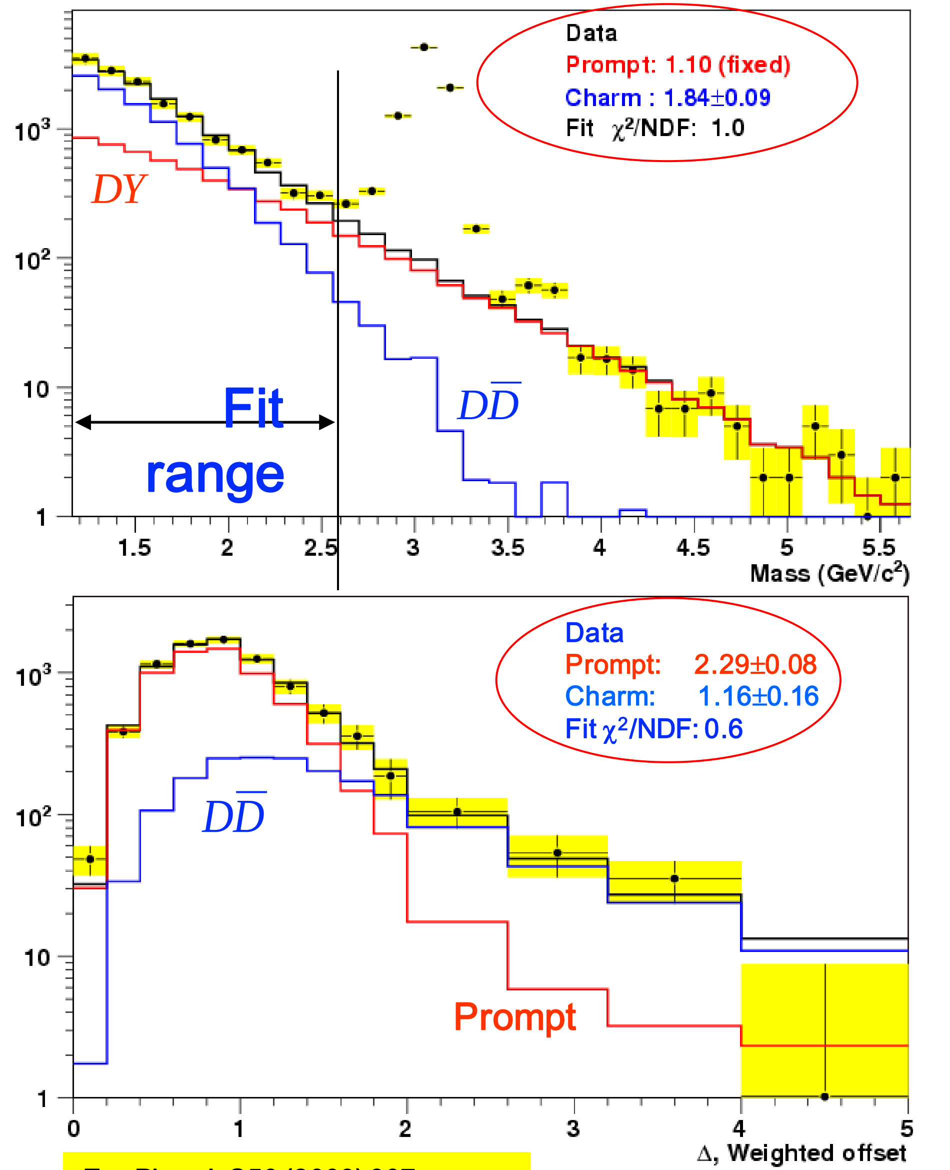


- charm can't describe the small offset region!

How many prompt pairs are needed?

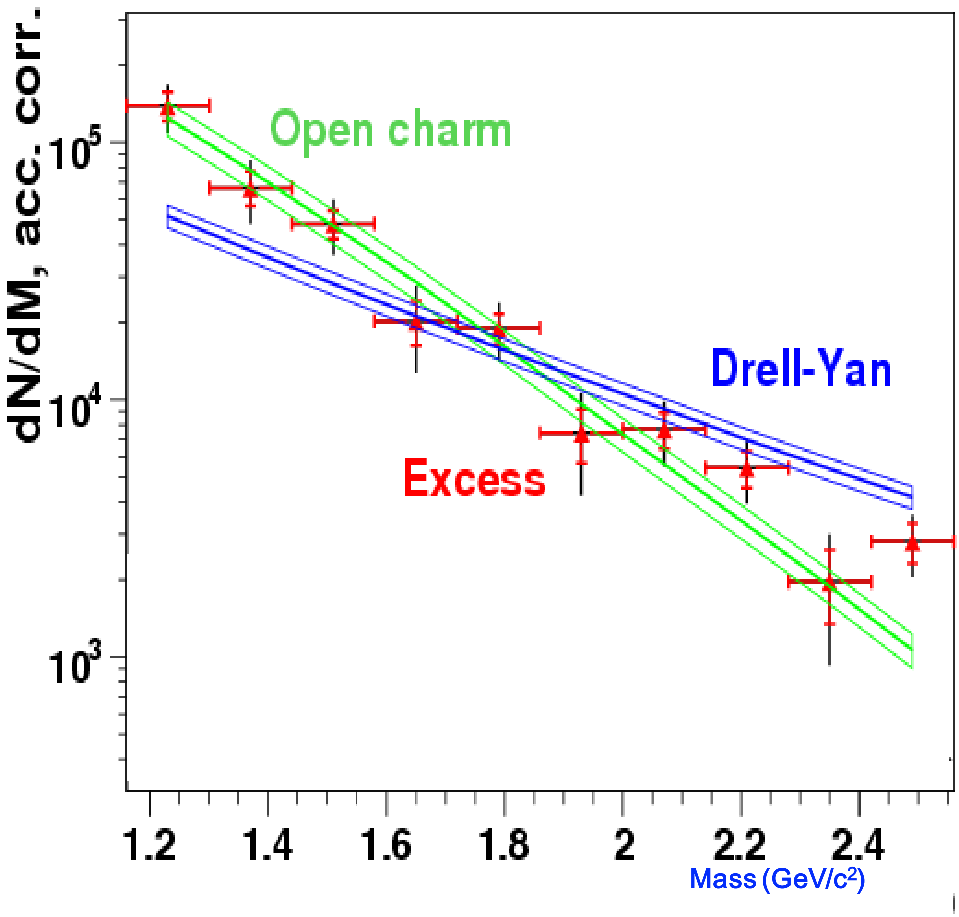
- approach
  - fit offset distribution with both charm and prompt contributions as free parameters
- prompt component
  - ~2.4 times larger than Drell-Yan contribution
- charm component
  - ~70% of the yield extrapolated from NA50's p-A data



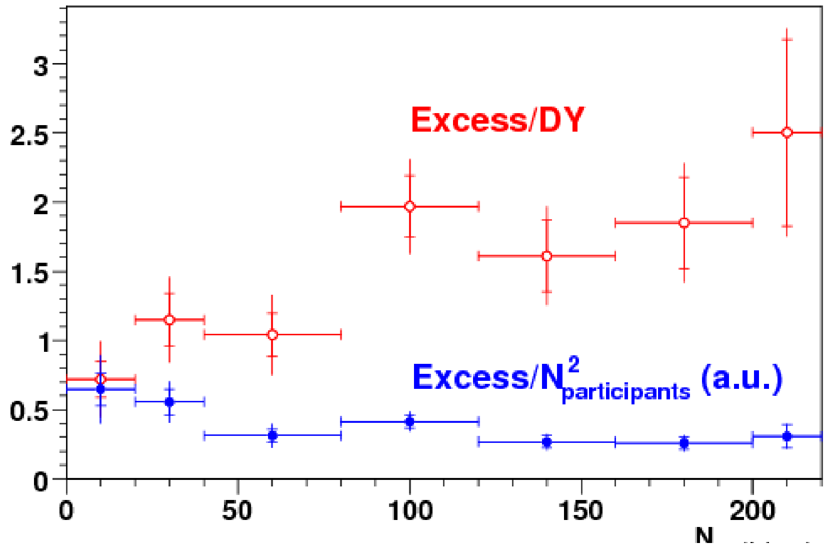
Eur.Phys.J. C59 (2009) 607

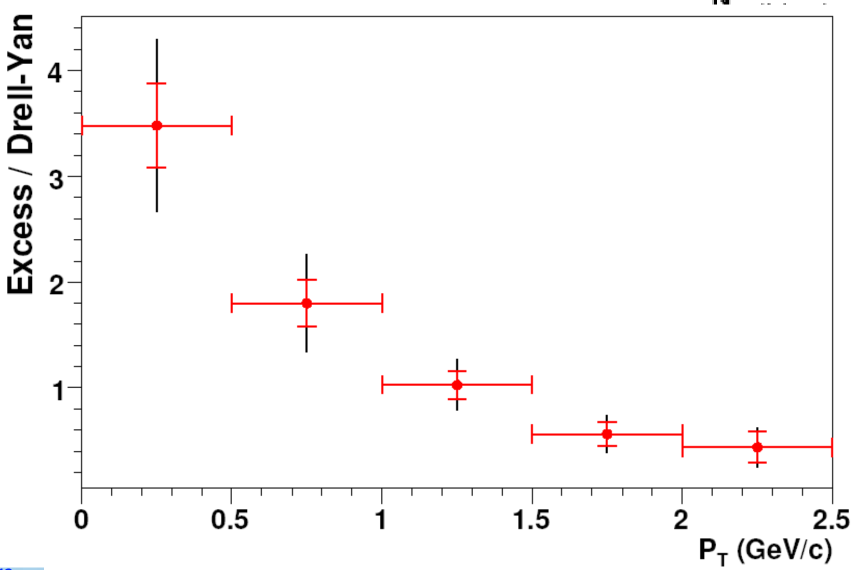
Decomposition of mass spectrum

- IMR: 1.16 < M < 2.56 GeV/c^2 (between ϕ and J/ψ)
- definition of excess
  - excess = signal – [Drell-Yan (1.0 ± 0.1) + Charm (0.7±0.15)]



Centrality & p_T dependence of IMR excess





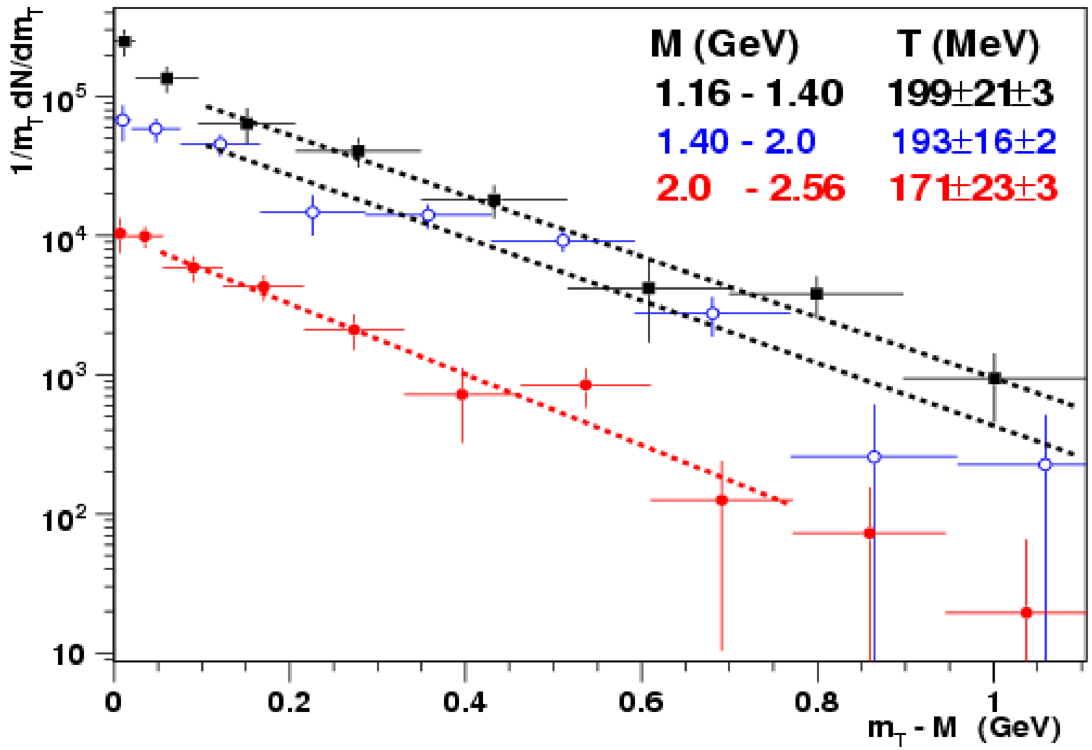
- increase more than proportional to N_{part}
- but also more than proportional to N_{coll}!

- p_T distribution is significantly softer than the (hard) Drell-Yan contribution: rules out higher-twist DY? [Qiu, Zhang, Phys. Lett. B 525, (2002) 265]

More detailed look at p_T dependence

- investigate excess in different mass regions as function of m_T
  - fit with exponential function (shown for IMR)
  - extract T_{eff} slope parameter

$$\frac{dN}{m_T dm_T} \propto e^{-m_T / T_{eff}}$$



- $\langle T_{eff} \rangle \sim 190$ MeV
  - is this related to temperature?
  - if so, this is close to the critical temperature at which the QCD phase transition occurs

HGS-HIRe Lecture Week

24-31/01/10 Manigod

Alberica Toia

Interpretation of T_{eff}

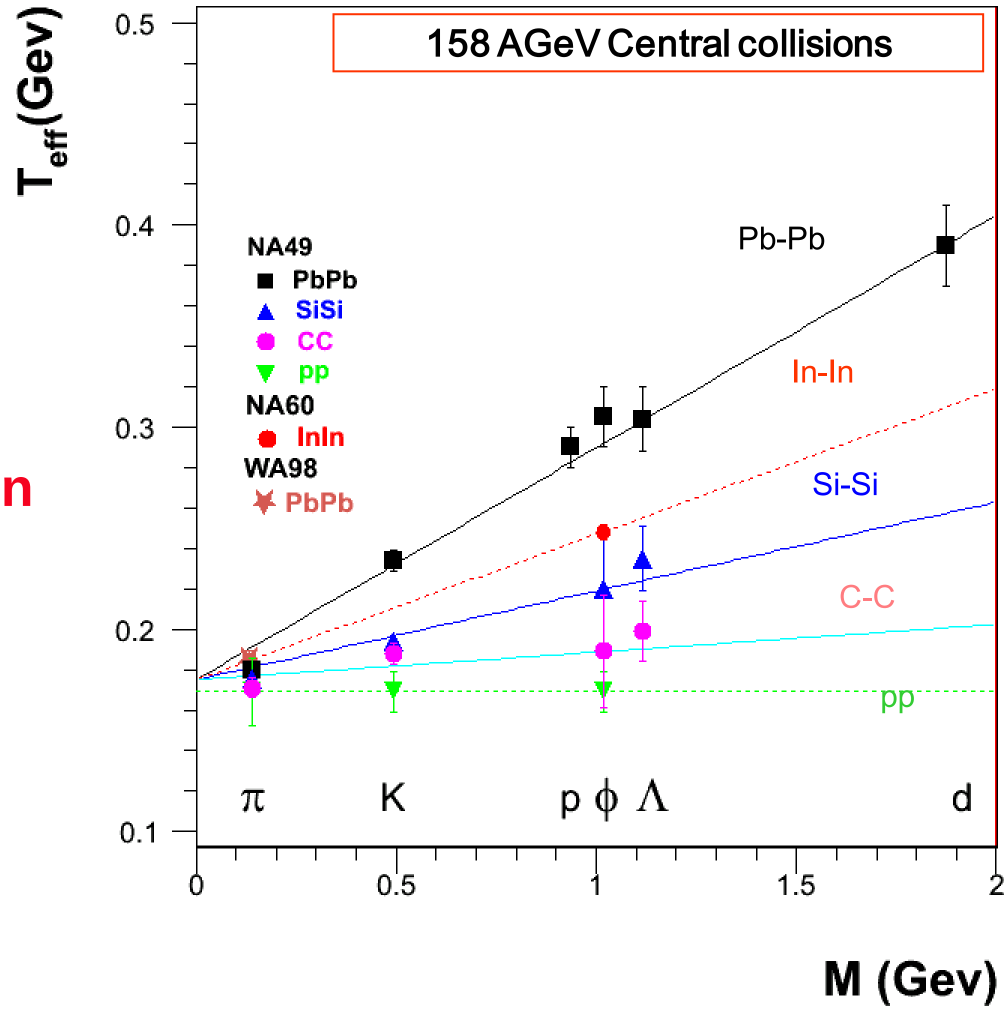
- **interpretation of T_{eff} from fitting to $\exp(-m_T/T_{eff})$**
  - **static source: T_{eff} interpreted as the source temperature**
  - **radially expanding source:**
    - –T_{eff} reflects temperature and flow velocity
    - –T_{eff} dependens on the m_T range
    - –large p_T limit: $T_{eff} = T_f \sqrt{\frac{1+v_T}{1-v_T}} \quad p_T >> m$ common to all hadrons
    - –low p_T limit: $T_{eff} \approx T_f + \frac{1}{2} m \langle v_T \rangle^2 \quad p_T << m$ mass ordering of hadrons
- **final spectra: space-time history $T_i \rightarrow T_{fo}$ & emission time**
  - **hadrons**
    - –interact strongly
    - –freeze out at different times depending on cross section with pions
    - –T_{eff} → temperature and flow velocity at thermal freeze out
  - **dileptons**
    - –do not interact strongly
    - –decouple from medium after emission
    - –T_{eff} → temperature and velocity evolution averaged over emission time

Mass ordering of hadronic slopes

- separation of thermal and collective motion
- reminder
  - blast wave fit to all hadrons simultaneously
- simplest approach

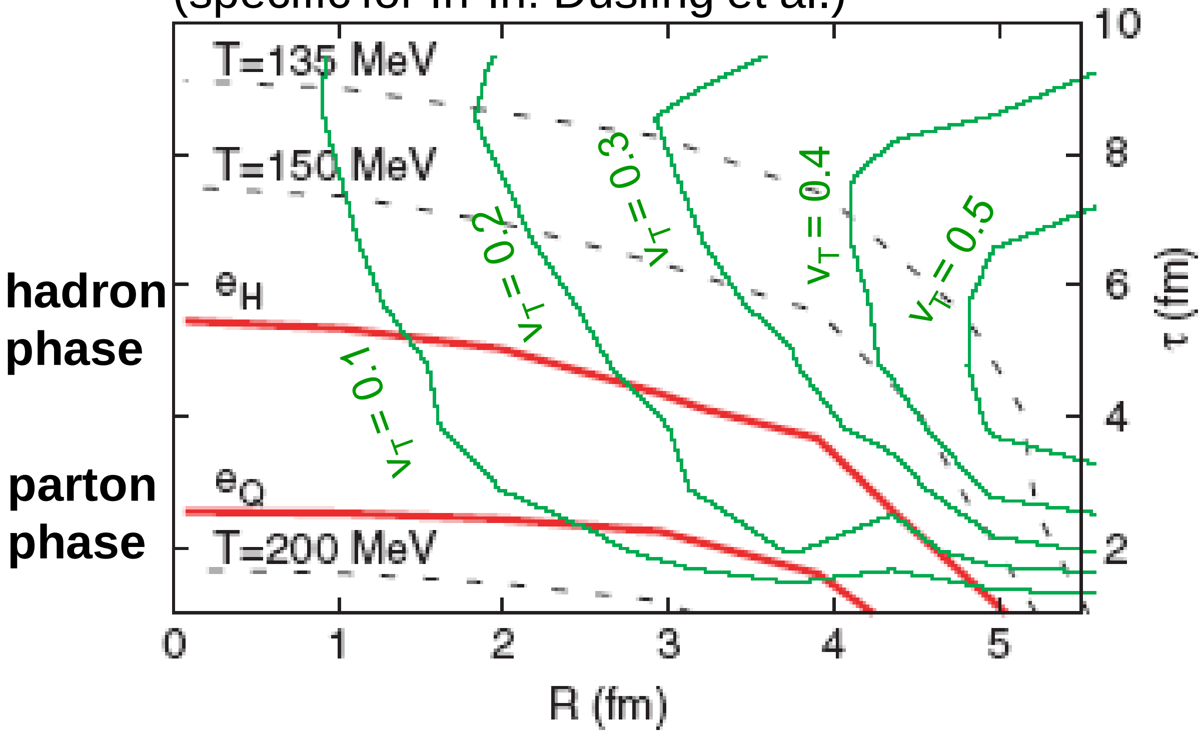
$$T_{eff} \approx T_f + \frac{1}{2} m \left\langle v_T \right\rangle^2 \quad p_T << m$$

  - slope of $<T_{eff}>$ vs. m is related to radial expansion
  - baseline is related to thermal motion
- works (at least qualitatively) at SPS



Example of hydrodynamic evolution

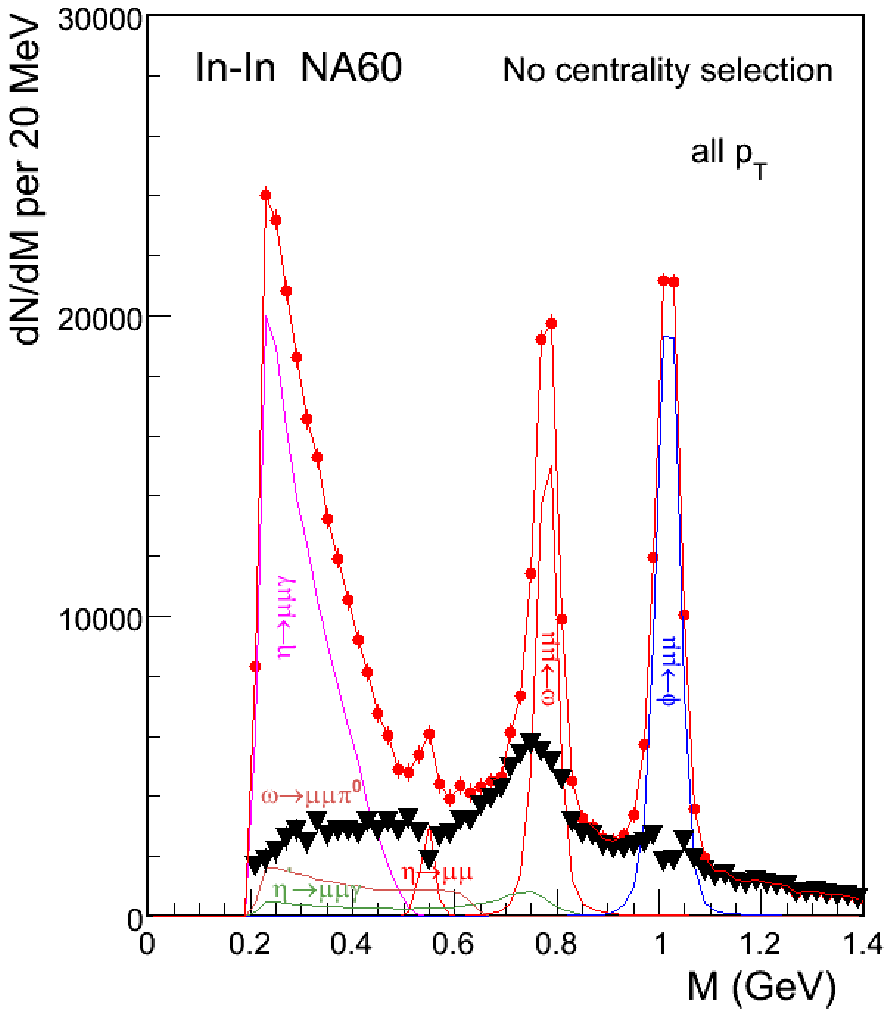
(specific for In-In: Dusling et al.)



- monotonic decrease of T from
  - early times to late times
  - medium center to edge
- monotonic increase of v_T from
  - early times to late times
  - medium center to edge
- dileptons may allow to disentangle emission times
  - early emission (parton phase)
    - large T, small v_T
  - late emission (hadron phase)
    - small T, large v_T

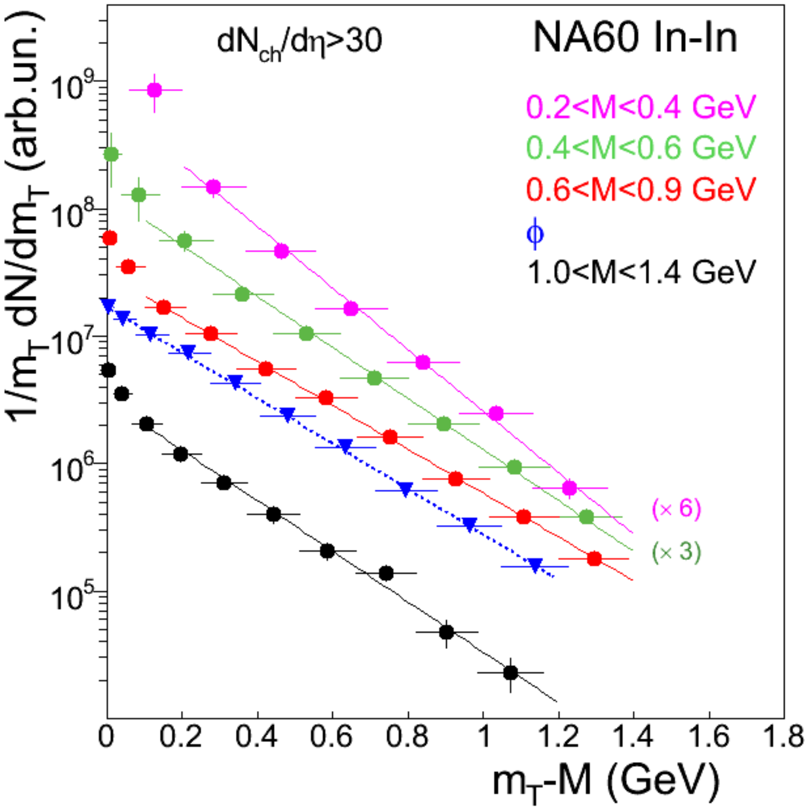
NA60 analysis of m_T spectra in In-In

Phys. Rev. Lett. 96 (2006) 162302

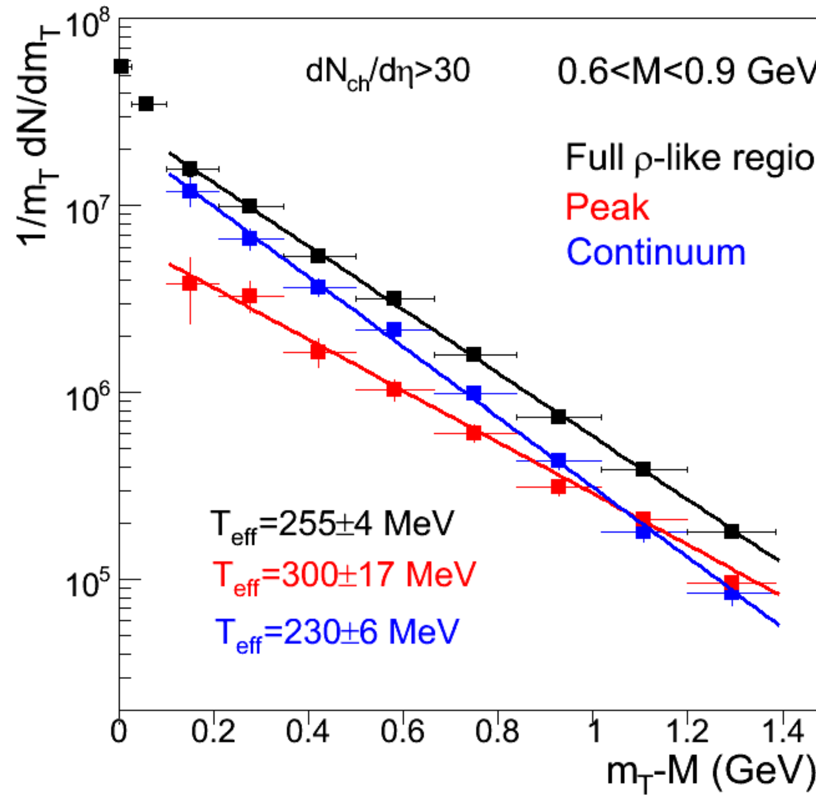


- **decomposition of low mass region**
  - **contributions of mesons (η,ω,φ)**
  - **continuum plus ρ meson**
  - **extraction of vacuum ρ**
- **hadron m_T spectra for**
  - **η,ω,φ**
  - **vacuum ρ**
- **dilepton m_T spectra for**
  - **low mass excess**
  - **intermediate mass excess**

Examples of m_T distributions



- variation with mass are obvious



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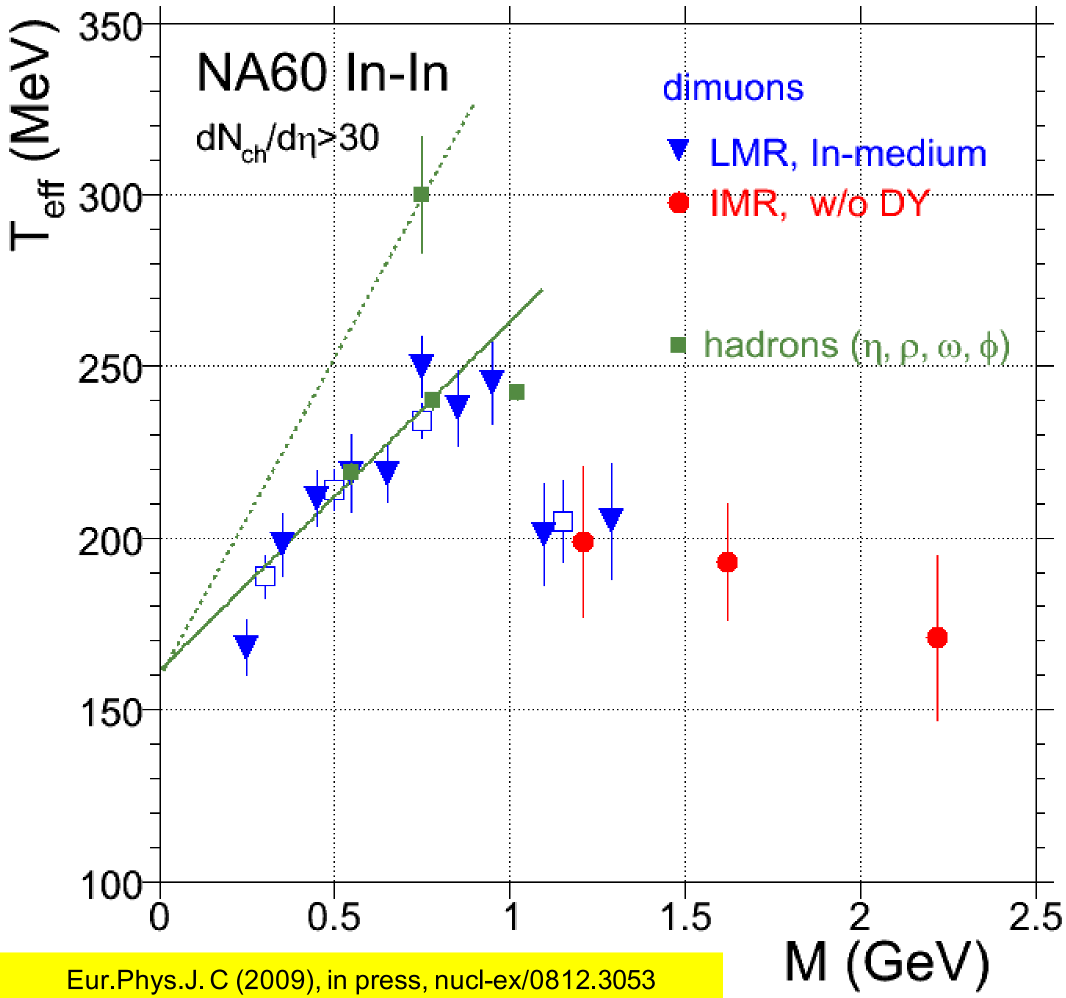
Dilepton T_{eff} systematics

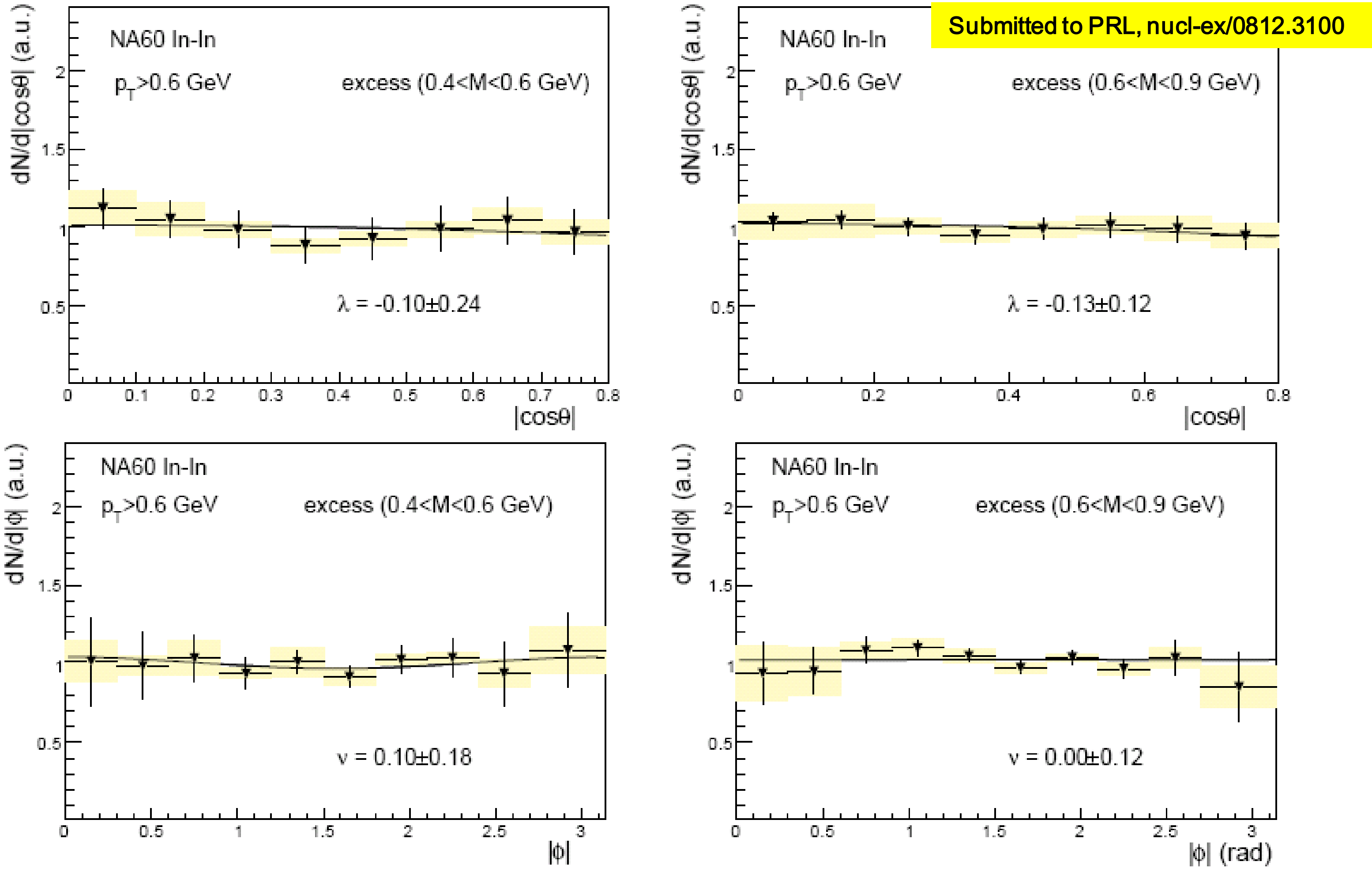


Eur.Phys.J. C (2009), in press, nucl-ex/0812.3053

- **hadrons (η, ω, ρ, ϕ)**
  - **T_{eff} depends on mass**
  - **T_{eff} smaller for ϕ, decouples early**
  - **T_{eff} large for ρ, decouples late**
- **low mass excess**
  - **clear flow effect visible**
  - **follows trend set by hadrons**
  - **possible late emission**
- **intermediate mass excess**
  - **no mass dependence**
  - **indication for early emission**

Polarization of dileptons

Submitted to PRL, nucl-ex/0812.3100

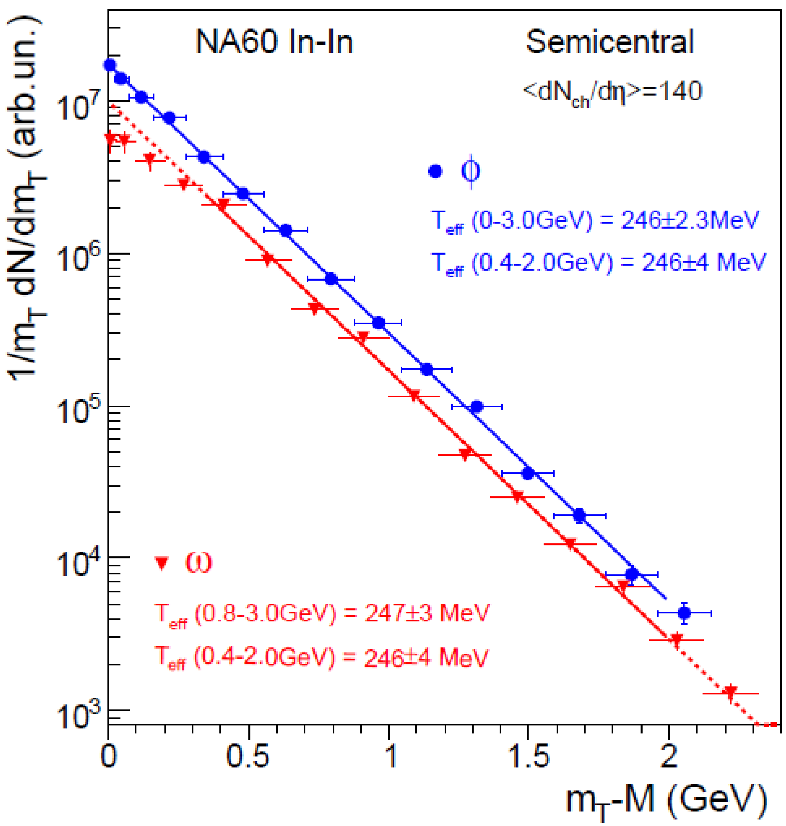


NA60 also measured the polarization (in the Collins-Soper frame) for $m \leq m_\phi$

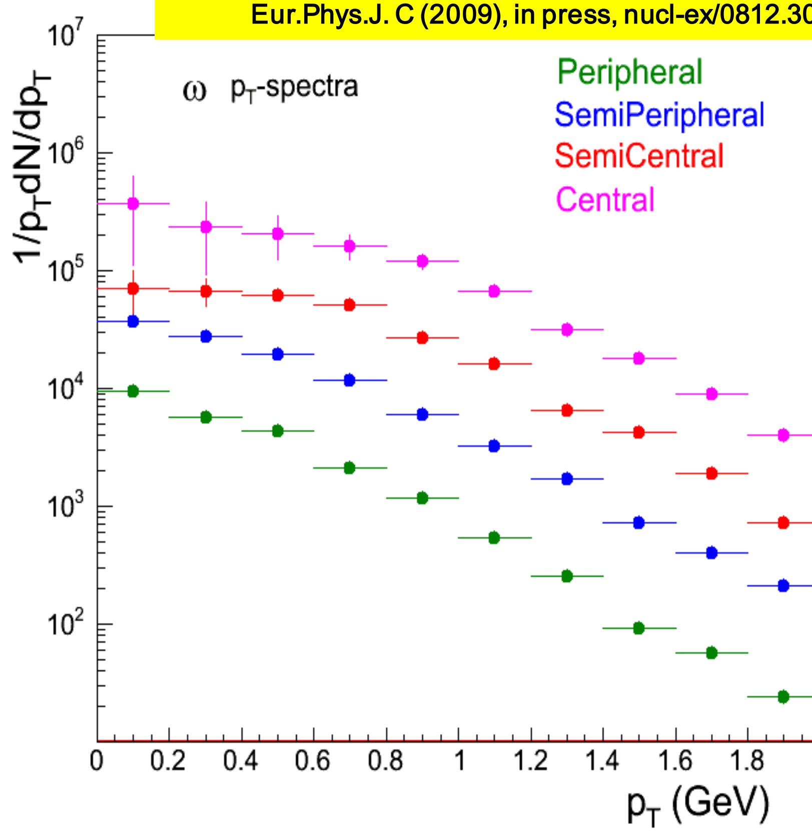
$$\frac{1}{\sigma}\frac{d\sigma}{d\Omega} \propto 1+\lambda\cos^2\theta+\mu\sin 2\theta\cos\phi+\frac{\nu}{2}\sin^2\theta\cos 2\phi$$

Lack of any polarization in excess (and in hadrons) supports emission from thermalized source.

Evidence of ω in-medium effects?



Eur.Phys.J. C (2009), in press, nucl-ex/0812.3053



Flattening of the p_T distributions at low p_T, developing very fast with centrality.

Low-pT ω's have more chances to decay inside the fireball ?

Appearance of that yield elsewhere in the spectrum, due to ω mass shift and/or broadening, unmeasurable due to masking by the much stronger $\pi\pi \rightarrow \mu\mu$ contribution.

Disappearance of yield out of narrow ω peak in nominal pole position

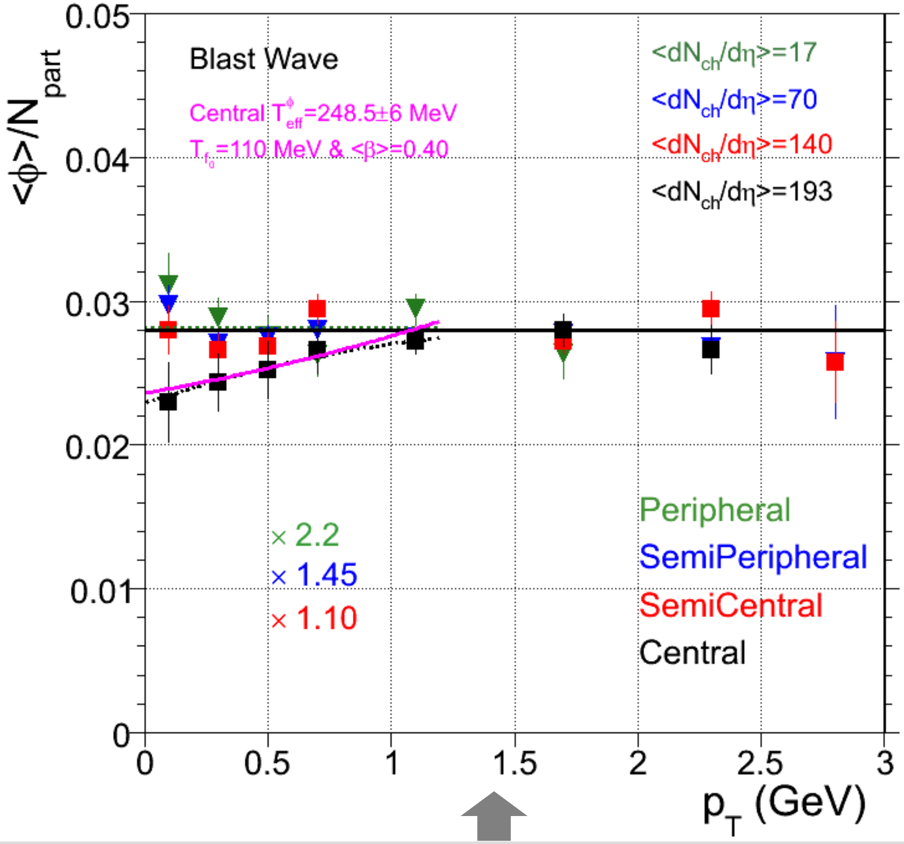
⇒ Can only measure disappearance

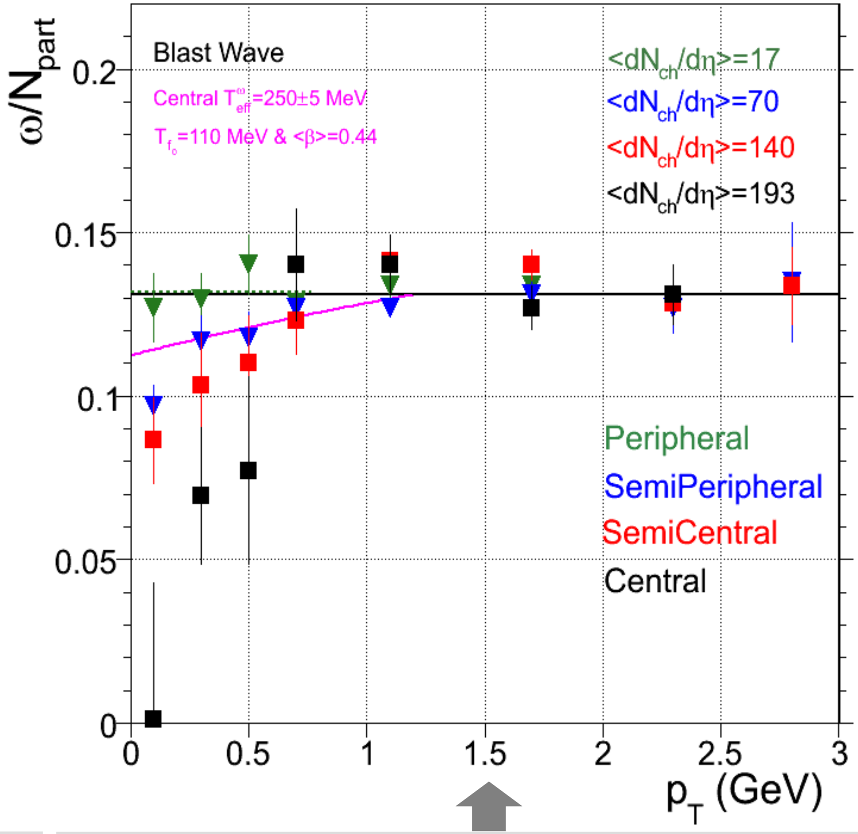
ω yield suppression

Determine suppression vs p_T with respect to $dN/dm_T^2 \sim \exp(-m_T/T_{eff})$ (extrapolated from p_T>1GeV/c)

Eur.Phys.J. C (2009), in press nucl-ex/0812.3053

Account for difference in flow effects using the results of the Blast Wave analysis





Reference line: ϕ/N_{part} = 0.0284 f.ph.s. (central coll.)

Consistent with radial flow effects

Reference line: ω/N_{part} = 0.131 f.ph.s.

Strong centrality-dependent suppression at p_T<0.8 GeV/c , beyond flow effects

What did we get from NA60?

- high statistics & high precision dimuon spectra
- decomposition of mass spectra into “sources”
- gives access to in-medium ρ spectral function
- data consistent with broadening of the ρ
- data do not require mass shift of the ρ
- large prompt component at intermediate masses
- dimuon m_T spectra promise to separate time scales
  - low mass dimuons shows clear flow contribution indicating late emission
  - intermediate mass dimuons show no flow contribution hinting toward early emission